Technical Report 643

Army Maintenance Training and Evaluation Simulation System (AMTESS) Device Evaluation:

Volume II. Transfer-of-Training Assessment of Two Prototype Devices

Kenneth W. Unger and Robert W. Swezey
Behavioral Sciences Research Center
Science Applications, Inc.

Robert T. Hays and Angelo Mirabella
Army Research Institute

Training and Simulation Technical Area
Training Research Laboratory

U. S. Army
Research Institute for the Behavioral and Social Sciences

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Students from several MOS were trained to perform maintenance tasks using either conventional methods or one of two AMTESS (Army Maintenance Training and Evaluation Simulation System) devices. All students were subsequently tested on operational equipment.

Approximately 30% of the comparisons made between device-trained and conventionally trained students indicated statistically superior performance by the conventionally trained students; however, inferior performance by the

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simulator-trained students might be attributed to the way in which the devices are presently configured. (For example, the simulated diesel engine sits on a table and is easier to work on than an engine sitting in the well of a real vehicle.) A transfer-of-training index termed the E/C ratio (scores of the experimental group divided by the scores of the conventionally trained group, multiplied by 100) indicated a high level of transfer in all cases. Results will be used to guide future AMTESS development efforts.

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Kenneth W. Unger and Robert W. Swezey
Behavioral Sciences Research Center
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Robert T. Hays and Angelo Mirabella
Army Research Institute

Submitted by
Robert J. Seidel, Chief
Training and Simulation Technical Area

Approved as technically adequate
and submitted for publication by
Harold F. O'Neil, Jr., Director
Training Research Laboratory

U.S. ARMY RESEARCH INSTITUTE FOR THE BEHAVIORAL AND SOCIAL SCIENCES
5001 Eisenhower Avenue, Alexandria, Virginia 22333-5600

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Training and Simulation

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FOREWORD

The Army Maintenance Training and Evaluation Simulation System (AMTESS) program, administered by the Army's Project Manager-Training Devices (PM-TRADE), is intended to develop a family of devices which can be used to train personnel in tasks required by a range of Military Occupational Specialties (MOS). The Army Research Institute (ARI) is evaluating this program in support of PM-TRADE.

Previous ARI reports have examined the features required by such a training simulator and the type of analysis needed to set up a testing program for the device. This report gives the results of quantitative and qualitative field testing of two prototypes. These results should prove valuable in designing future maintenance simulators.

The next step in the AMTESS program will be laboratory research at George Mason University in Fairfax, Virginia. This research, performed under ARI contract, will test the AMTESS devices under scientifically controlled circumstances.

Edgar M. Johnson

EDGAR M. JOHNSON
Technical Director

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ARMY MAINTENANCE TRAINING AND EVALUATION SIMULATION SYSTEM (AMTESS) DEVICE EVALUATION: VOLUME II, TRANSFER-OF-TRAINING ASSESSMENT OF TWO PROTOTYPE DEVICES

EXECUTIVE SUMMARY

Requirement:

The objective of the Army Maintenance Training and Evaluation Simulation System (AMTESS) program is to provide the Army with a family of generic maintenance trainers. During Phase I of this program, four conceptual versions of AMTESS devices were developed. During Phase II, two prototype AMTESS devices were fabricated. This report describes a transfer-of-training assessment of the two prototype AMTESS devices.

Procedure:

Students from several MOS and two sites were trained to perform maintenance tasks with conventional methods (lectures and "hands-on" experience) or with one of the two AMTESS simulators. All subjects were subsequently tested on their ability to perform these tasks on operational equipment.

Findings:

In all cases, students trained on the prototype simulators were able to pass the Army school's criterion for the chosen tasks. In the majority of comparisons between training conditions, simulator-trained students performed almost as well as conventionally trained students. Approximately 30% of the comparisons made between the two training conditions indicated superior performance by the conventionally trained students. In many cases, however, differences between the conditions were not of practical importance. Both AMTESS devices were found to provide an acceptable level of training in each of two widely different maintenance contexts, encompassing both mechanical and electronic maintenance training situations.

Utilization of Findings:

Results of this effort should provide guidance for future AMTESS development efforts.

ARMY MAINTENANCE TRAINING AND EVALUATION SIMULATION SYSTEM (AMTESS) DEVICE EVALUATION: VOLUME II, TRANSFER-OF-TRAINING ASSESSMENT OF TWO PROTOTYPE DEVICES

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INTRODUCTION

Weapon systems currently used by the Army are both more expensive and more sophisticated than previous systems. Consequently, it has become increasingly important for the Army to develop a well-trained corps of maintenance personnel. This task is complicated by the fact that no single proponent agency for maintenance training exists in the Army. Instead, the Commandant of each Army School is responsible for the life-cycle training of maintenance MOSs appropriate to that School. Maintenance training is further complicated by the extraordinary diversity of skill levels, tasks, and equipment involved in maintenance MOSs.

Although the Army has traditionally used operational equipment for maintenance training, this has been shown to be less than satisfactory for a number of reasons:

- o Equipment may be damaged during training.
- o Students may be injured during operation of hazardous equipment.
- o Availability of operational equipment is limited.
- o Use of operational equipment limits students' ability to practice certain malfunctions due to possible equipment damage and risk of injury to students.

The Army has recognized these problems and, in response, has defined new training device concepts such as the Army Maintenance Training and Evaluation Simulation System (AMTESS) (Dybas, 1981, 1983).

AMTESS Program Objectives and Requirements

The objective of the AMTESS program is to provide the Army with cost- and training-effective maintenance simulators which can provide for effective training over the next five to ten years. These devices must:

- o support introductory weapon/operational system training at the institution level,
- o support unit-level proficiency training,
- o combine "heads-on" and "hands-on" training,
- o provide training which is self-paced and adaptive,

- provide feedback to the student,
- provide for the automated "hands-on" administration of SQTs,
- exhibit cost effectiveness,
- adapt to a range of Army needs, and
- capitalize on recent advances in video storage, microelectronics, and interactive graphics.

Developing such a training and evaluation system requires the creative combination of instructional, computer, and simulation technologies. The hardware and software must be:

- modular in configuration to permit ease of component interchange and custom configuration for a particular application,
- closed-loop in design to provide appropriate responses to student inputs,
- generic in construction to assure multiple vendor producibility, low cost, and type classification,
- modifiable by Army personnel to allow easy updating, and
- adaptable to a variety of instructional uses and operating environments.

In Phase I of the AMTESS program, four different conceptual versions of generic maintenance trainers were developed by four separate contractors. During Phase II of the program, two contractors, Grumman Aerospace Corporation and a consortium of Seville Research Corporation and Burtek, Inc., were chosen to develop breadboard models of their conceptual designs. The designs both involved a microprocessor-based core component having a two-dimensional visual display (CRT) to which could be attached peripheral three-dimensional mock-ups of appropriate hardware (i.e., a simulated Cummins diesel engine) depending upon the MOS to which the device was applied. The functioning of the mock-up was, in both cases, controlled by the microprocessor via uniquely developed software. Both devices were designed to be modular and reconfigurable. If the devices are to be used in another MOS, then only the "core" components are designed to remain the same, with only the peripheral equipment designed to simulate the appropriate piece of hardware requiring modification. The Seville/Burtek device was based upon a 35mm rear projection visual display system, whereas the Grumman device employed a videodisc-based system. Previous reports in this series have considered the AMTESS program from the perspectives of device features (Criswell, Unger, Swezey, & Hays, 1983) and front-end analytic activities (Woelfel, Duffy, Unger, Swezey, Hays, & Mirabella, 1984).

The simulators addressed different MOSs at Aberdeen Proving Ground, Maryland (APG). The Grumman simulator was designed to accommodate the 63D30 MOS (Self-propelled Field Artillery Systems Mechanic), while the Seville/Burtek simulator was designed to support tasks performed in the 63W10 MOS (Wheeled Vehicle Repairman). Different configurations of these devices were also designed to address the 24C10 MOS (Hawk Missile Firing Section Mechanic) at Fort Bliss, Texas. Thus, the core components of both simulators were generic in the sense that they were capable of supporting widely different maintenance training tasks (i.e., both mechanical and electronic maintenance).

An issue of importance to the AMTESS program concerns the effectiveness of the training provided by the prototype devices. Training effectiveness may be determined by assessing the extent to which a trainee's performance on operational equipment is affected by previous simulator-based training. Transfer of training is demonstrated when the existence of a previously learned behavior influences the acquisition or retention of a subsequent behavior. Thus, if a trainee learns to perform a task via simulator-based training, and if this training influences ability to perform the task on operational equipment, transfer of training has occurred. Transfer may be positive for some tasks and negative for other tasks. To the extent that transfer effects are positive, the simulator may reduce dependence on operational equipment during training.

A typical simulation transfer-of-training study involves two groups of students: an experimental group that receives simulator training prior to performance testing on operational equipment, and a conventionally trained group that receives training on the relevant operational equipment prior to performance testing on the operational equipment. If care is taken to equate the two groups on other relevant factors, then differences in performance on operational equipment can be attributed to the influence of training received by the two groups. Although various types of data are included in the evaluation of the AMTESS devices (interviews, questionnaires, reliability data), only transfer-of-training data provide a direct measure of the training effectiveness of the devices.

Evaluation Design Issues

The original evaluation plan (Smith & Hirshfeld, 1981) called for three separate experiments, as shown in Table 1. Three experiments were required because the Seville/Burtek and Grumman simulators addressed different tasks at APG. The experiments were originally intended to run over a 7-month period, with the two breadboard devices to be switched between Fort Bliss and APG after three months of testing. This design was abandoned when delivery of the breadboard devices was delayed over eight months beyond the originally anticipated dates. Also, since the two breadboard devices were not completed and delivered at the same time, it was impossible to evaluate them simultaneously.

Table 1

Original Experimental Design

<table>
<tr><td colspan="3">Experiment 1</td><td>Experiment 2</td><td>Experiment 3</td></tr>
<tr><td colspan="3">Fort Bliss, TX</td><td>Aberdeen, MD</td><td>Aberdeen, MD</td></tr>
<tr><td colspan="3">Month</td><td>Month</td><td>Month</td></tr>
<tr><td>1 2 3</td><td>4</td><td>5 6 7</td><td>1 2 3</td><td>5 6 7</td></tr>
<tr><td>Experimental Group (n=20) Trained on Seville/Burtek Device</td><td>Interim Period</td><td>Experimental Group (n=20) Trained on Grumman Device</td><td>Experimental Group (n=20) Trained on Grumman Device</td><td>Experimental Group (n=20) Trained on Seville/Burtek Device</td></tr>
<tr><td colspan="3">Conventionally Trained Group (n=20)</td><td>Conventionally Trained Group (n=20)</td><td>Conventionally Trained Group (n=20)</td></tr>
</table>

The original evaluation design also called for use of existing Army "hands-on" performance tests as the criterion measures for the transfer-of-training experiments. These tests were, however, found to be inadequate since they are designed to yield only GO/NO-GO information in broad categories which were not sufficiently detailed for purposes of the evaluation. Considerable resources were, therefore, devoted to developing new and dramatically expanded versions of these tests.

Instructor differences also complicated the evaluation design. Instructors varied widely in the manner in which they administered performance tests. Some maintained standardized, controlled conditions while others viewed testing as a learning experience and, consequently, "taught" during the performance testing. Considerable effort was, therefore, devoted to obtaining controlled testing conditions and standardized test equipment. Strict testing protocols were designed to reduce variance resulting from testing "style."

Various other problems also occurred due to circumstances involving the delivery of the prototypes. Both devices were delivered late, thereby reducing the total time available for evaluation. Further, a low and variable student flow sharply reduced the number of students available for testing and created an erratic testing schedule. This problem was exacerbated at Fort Bliss by the fact that school administrators at the U.S. Army Air Defense School required that students be tested simultaneously (as opposed to sequentially), thereby reducing dramatically the amount of data which could be collected by available on-site personnel.

A time line depicting the course of the evaluation activity is presented in Figure 1.

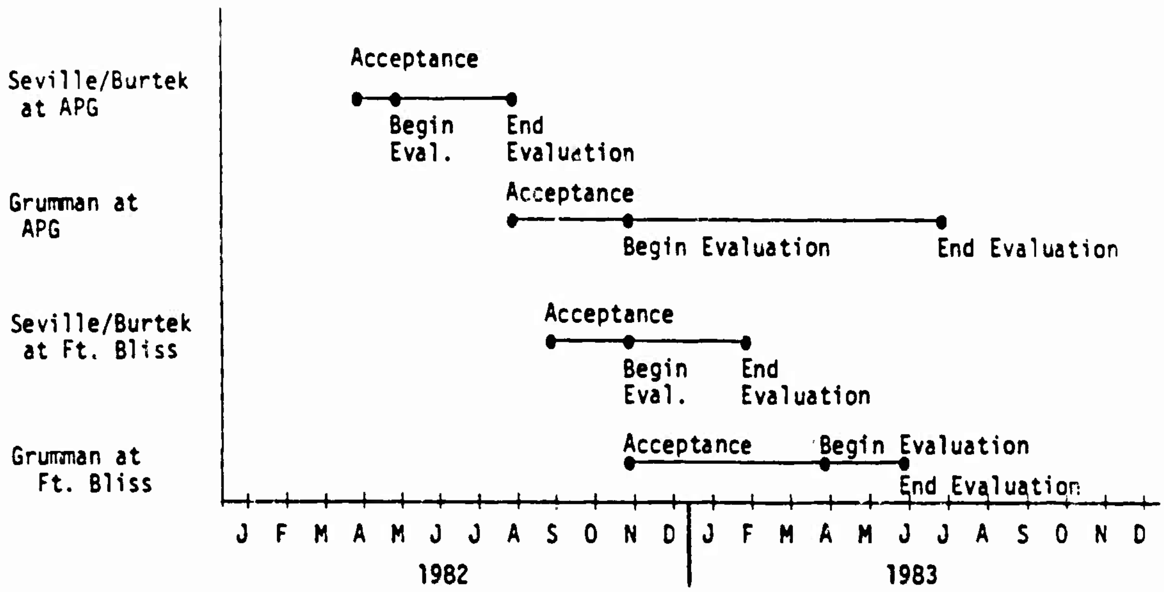

Figure 1. Time line for the evaluation of the Seville/Burtek and Grumman simulators at Aberdeen Proving Ground, Maryland and Fort Bliss, Texas.

Purpose of the Evaluation

The AMTESS training effectiveness evaluation reported herein cannot be considered as typical of training device evaluation efforts. The two breadboard simulators evaluated in this study were designed to demonstrate conceptual approaches to hardware, software, and courseware design. The purpose of the evaluation of these breadboard devices was to determine if, in fact, these conceptual approaches are worth further development. To make this determination, the evaluation was designed to provide data on the following questions:

- o Do the curricula associated with the AMTESS breadboard devices provide adequate training?
- o How does the training effectiveness of the AMTESS breadboard devices compare to the training effectiveness of conventional methods?
- o Is the AMTESS concept of modular training simulators feasible?

The remainder of this report details the experiments conducted to answer these questions.

Organization of This Report

This report describes a field training effectiveness study of the two AMTESS breadboard simulators. It is organized in three volumes. Volume I is an overview of the evaluation. This report is Volume II of the series. It is intended to address only the quantitative, transfer-of-training portion of the evaluation. Volume III reports data on additional relevant topics concerning attitudes of trainees, instructors, and course developers towards these devices.

In order to improve the clarity of communication, the research is presented as six separate experiments. The criterion measures employed in each experiment are presented in Table 2.

RESULTS OF EXPERIMENTS

Experiment 1

Experiment 1 addresses transfer-of-training issues involving the Seville/Burtek simulator at APG. In Experiment 1, 40 students studying to become wheeled vehicle mechanics were trained on four maintenance tasks using either the simulator or conventional training methods. The students were then tested on their ability to perform these tasks on an M809 series 5-ton truck having a Cummins diesel engine.

Method

Subjects. Forty students from MOS 63B30 (Organizational Maintenance Supervisor) participated in the first experiment. All students were Noncommissioned Officers (NCOs) who averaged eight years of military experience. Prior to entry into the 63B30 course, the majority of the NCOs were trained as organizational level mechanics in the following MOSs: 63S, Heavy Wheeled Vehicle Mechanic; 63G, Light Wheeled Vehicle and Power Generator Mechanic; and 63Y, Tracked Vehicle Mechanic. With few exceptions, the students had at least preliminary experience troubleshooting diesel engines.

Design. The design for Experiment 1 is presented in Figure 2. Twenty students received conventional training on an actual equipment trainer (AET), i.e., an M809 truck, and 20 students were trained using the curriculum associated with the Seville/Burtek simulator. All students were tested on the M809 truck. Since school performance tests upon inspection proved to be too general for the collection of adequate transfer-of-training data, new and more detailed test forms were developed, tested, and validated with help from School Subject Matter Experts (SMEs). Revised data collection forms were then developed by consulting technical manuals (TMs) and School SMEs to determine appropriate content. Preliminary versions of the test form were then pilot-tested and refined accordingly. Development of the revised tests is documented in an interim report by Unger and Swezey (1982). Both the original School performance tests and the

Table 2

Criterion Measures Employed in AMTESS Field Evaluation Studies

	EXPERIMENT					
	1	2	3	4	5	6
Device	S/B[a]	S/B	G[b]	G	S/B	G
MOS	63B30	63W10	63H30	63D30	24C10	24E, G, R
Location	APG[c]	APG	APG	APG	Bliss[d]	Bliss
Sample Size						
Simulator Group	20	21	10	12	10	10
Conventional Group	20	20	12	11	12	0
Number of Tasks Tested	4	5 subtasks	8 subtasks	8 subtasks	4	8
Criterion Measures						
E/C and C/E Ratios	X	X	X	X	X	
% Steps Passed	X	X	X	X	X	X
Time to Complete	X	X	X	X	X	X
Data Collector Interventions	X	X	X	X		
Other					Instructor Ratings School Exams	Case Study Approach
Number of Reclustered Tasks Tested	6	5	6	6		
Criterion Measures						
% Steps Passed	X	X	X	X		
Data Collector Interventions	X	X	X	X		

[a]S/B = Seville/Burtek
[b]G = Grumman
[c]APG = Aberdeen Proving Ground, MD
[d]Bliss = Fort Bliss, TX

revised versions used in this study are presented in Appendix A. The revised forms were designed to provide for collection of five types of information:

- Student identification and background
- GO/NO-GO scores for each step on the performance test
- Number of data collector interventions required during testing

  NOTE: Data collector interventions were determined to be required in various situations: either for reasons of safety or to speed up the test administration in situations where students were simply not able to perform a step in the testing protocol.

- Time to complete each task and subtask
- Comments concerning any relevant details about the subject or the testing situation

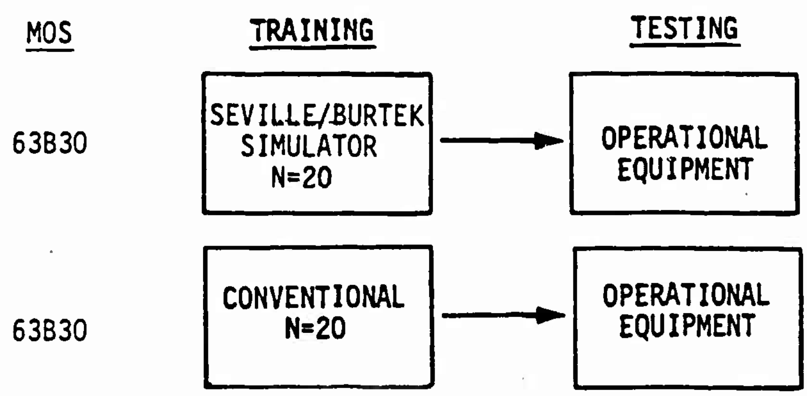

Figure 2. Design of Experiment 1.

As previously noted, a great deal of data not directly addressing transfer of training was also collected. These data consist of:

- Initial instructor questionnaires (i.e., administered before simulator-based training began)
- In-depth instructor and course developer questionnaires (i.e., administered after simulator-based training had been accomplished)

- o NHC-26: Troubleshoot and repair electrical system (battery switch failure)

Although instructional material comprising 28 lessons was available in the curriculum supporting the Seville/Burtek simulator, many lessons were unsuitable for inclusion in the study. Some tasks taught on the simulator were determined by the Army to be infeasible for teaching or for testing on operational equipment (for reasons of safety, numbers of instructor personnel required, etc.). Further, since a great deal of redundancy existed in the 28 lessons, only a subset of lessons included in the training curriculum which supported the simulator were used in the evaluation.

Conventionally trained students participated in the normal U.S. Army Ordnance Center and School instructional curriculum for the 63B30 MOS, which included training in all tasks relevant to the evaluation. These students were briefed by an instructor on the M809 truck and the NHC-250 diesel engine. Under the supervision of an instructor, students then used TMs and various tools in order to perform troubleshooting tasks on the vehicle. The instructor queried students and guided their actions as they performed troubleshooting activities on the vehicle.

Students were tested on their ability to perform the following four tasks:

- o Troubleshoot oil pump failure (organizational level only)
- o Adjust the alternator drive belts
- o Remove/replace the starter motor
- o Inspect the electrical system

Testing was conducted individually for all students. All testing was conducted by the SAI data collector For the majority of students, administration of the performance test took place within a 24-hour period following the completion of training. Two students were tested outside this 24-hour period due to events which were outside experimental control.

The performance evaluation was designed so that testing on the sequence of four tasks could be accomplished in one session per student. Exceptions to this were held to a minimum and were due to variables that could not be controlled. For example:

- o Scheduled breaks for lunch, coffee, parade practice, etc.
- o Malfunctioning test equipment
- o Military personnel requiring access to the test vehicle

- o Damaged or malfunctioning components on the test vehicle

- o Unscheduled interruptions, such as fire drills

Whenever possible, students were required to complete a task before testing was stopped for unscheduled reasons. If this was not possible, then upon resumption of testing, the student was briefed as to what he had accomplished prior to the break. This was an effort to control for the interruption in the student's train of thought during unscheduled breaks in testing.

Prior to the start of testing, all required manuals, tools, and equipment were assembled at the test station. Testing began after students had been briefed on the appropriate problem and after student questions had been answered. Students required approximately two hours to complete the four tasks involved in the experiment.

Authorities at APG would not permit interference with the flow of student progress through the standard school curriculum. Therefore, although 25 students were trained on the simulator, only 20 were available for testing. All 20 conventionally trained students were tested. Both groups of students were trained by the same instructor.

Results

An analysis of student background data was conducted to determine if significant differences existed between the simulator-trained and the conventionally trained students prior to the beginning of training. In terms of age, grade, and Armed Services Vocational Aptitude Battery (ASVAB) (i.e., general maintenance, mechanical maintenance, general technical, and electronics) scores, t-tests revealed no statistically significant differences between the trainees assigned to the conventional training group and those assigned to the simulator-based training group. Trainee characteristics are presented in Table 3.

Three dependent variables were of interest in the between-group training effectiveness comparisons: the percentage of performance test steps passed, the length of time required to complete each tested task, and the number of interventions which were required in the test administration.[1] For each of these variables, the performance of the two groups of students was compared by dividing the scores of one group by the scores of the other group and multiplying the result by 100. The value which results, known as E/C (or C/E) ratio indicates the extent to which the performance of one group (experimental or conventional) approaches that of the other.

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[1] See Appendix A for a copy of the relevant performance tests.

Table 3

Characteristics of Trainees Involved in Experiment 1

Characteristic	Simulator Training	Conventional Training
Age:		
Mean	25.95	25.67
Standard Deviation	2 69	2.35
Grade: Range	E4-E5	E4-E6
ASVAB Scores:		
General Maintenance		
Mean	100.56	98.75
Standard Deviation	18.58	14.32
Mechanical Maintenance		
Mean	108.13	104.75
Standard Deviation	13.17	13.94
General Technical		
Mean	99.63	98.83
Standard Deviation	16.92	14.50
Electronics		
Mean	104.88	99.17
Standard Deviation	14.07	13.35

Subsequently, a series of 27 t-tests was computed in an attempt to detect statistically significant differences between conventionally trained and simulator-trained groups.[2] Since there was no reason to expect that the simulator-trained group would perform better than (or worse than) the conventionally trained group, two-tailed tests were computed. For several measures, scores in the simulator-trained group exhibited high score variances. In such cases, scores were transformed in order to achieve more homogeneous variances; however, since it was determined that application of the data transformations did not effect the outcome of any statistical test, the results reported herein are those based upon the untransformed (raw) data.

In an effort to determine if differences in specific skills and knowledges existed between the conventionally trained and the simulator-trained groups, the original tasks performed by the students were reclustered into a set of more homogeneous tasks, i.e., TM selection, mechanical inspection, remove/replace, hook-up, control actuation (activating switches, knobs, buttons, etc.), and instrument reading.[3] Data based upon these reclustered tasks were also analyzed in terms of percentage of performance steps passed and number of data collector interventions.

<u>E/C and C/E Ratios</u>. A direct comparison of the percent steps passed scores can be made by dividing the experimental (E) scores by the conventional (C) scores and multiplying the result by 100. The resulting value indicates the extent to which experimental group performance approaches that of the conventionally trained group. Scores greater than 100 indicates that performance by the experimental (i.e., simulator-trained) group exceeds that

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[2]Multiple t-tests were selected as the preferred method of data analysis in Experiments 1 and 2 because, due to School imposed constraints and inadequate student flow, cross-MOS and cross-experiment comparisons were not feasible. Further, the small sample sizes involved imposed limited degrees of freedom upon the statistical comparisons, thus, effectively eliminating multivariate and ANOVA-based approaches. Although numerous t-tests were computed in Experiment 1 (and also in Experiment 2) and results having an alpha level of $p<.05$ were accepted as indicating significant between-group differences (as is conventional in research studies of this sort), as in any statistical comparison, care must be exercised in interpreting outcomes. Various confounding and/or artifactual events may have affected the results of the statistical comparisons (including sampling error, inadequate test coverage, and flawed performance measures, among others). Also, due to the large numbers of statistical comparisons made, some may have evidenced significance due to chance alone. (At an alpha level of $p<.05$, for example, this chance is approximately one in 20, whereas at a level of $p<.01$, it is approximately one in 100.) Because of such reasons as these, policy decisions (e.g., replacement of operational equipment with simulators), should not be based on statistical comparisons alone, but should also take other factors (such as safety and cost savings, for instance) into consideration.

[3]This reclustering was originally developed by Mirabella and Holman and reported in Evans and Mirabella (1982).

of the conventionally trained group. Table 4 presents E/C scores for percent steps passed for the 63B30 students. Inspection of this table reveals that scores of experimentally trained students exceeded those of conventionally trained students for two of the four tasks. Experimental scores were more than 90 percent as high as conventional scores for the remaining two tasks.

Table 4

E/C and C/E Ratios for 63B30 Students

Task	E/C Ratio Percent Steps Passe'	C/E Ratio Time to Complete Task	C/E Ratio Data Collector Interventions
Adjust alternator belts	101.03	88.49	66.67
Remove/replace starter motor	102.11	78.63	100
Oil pump failure (organizational)	94.94	51.91	75
Electrical system inspection	94.32	68.68	43.84
	$\bar{x}$ = 98.1	$\bar{x}$ = 71.93	$\bar{x}$ = 71.38

Since low score values indicate superior performance for the time to complete task measure and the data collector intervention measure, conventional (C) scores are divided by experimental (E) scores, and the result is multiplied by 100. The resulting value indicates the extent to which to which conventional group performance approaches experimental group performance. (For example, a C/E score of 75 for time to complete task indicates that conventionally trained students required 75% of the time required by experimentally trained students to complete a task.) Conventional/Experimental Ratio values exceeding 100 indicate that performance by the experimental group exceeds performance by the conventional group.

The C/E ratios for time to complete task indicate that conventionally trained students performed all four tasks faster than simulator-trained students. Conventionally trained students completed the four tasks in approximately 72% of the time required by the simulator-trained students to complete the tasks. (See Table 4.)

The C/E ratios for data collector interventions revealed identical performance by the two groups of students for the starter motor remove/replace task. For all other tasks, conventionally trained students required fewer data collector interventions than simulator-trained students. For all four tasks combined, conventionally trained students required approximately 71% of the data collector interventions that were required by simulator-trained students. (See Table 4.)

Percent Steps Passed. Data for the percent steps passed measure were obtained by dividing the number of steps in a procedural task upon which the student received a GO score by the number of steps which were attempted. An overall t-test comparing percent steps passed by the two groups of students (for all four tasks combined) revealed no significant differences in performance. Subsequent t-tests revealed no significant differences in performance between the two groups for any of the four tasks which were performed. Figure 3 presents these data.

Time to Complete Task. An overall t-test between the two groups indicated that for all tasks combined, conventionally trained students performed significantly faster than did simulator-trained students, $t(38) = 3.95$, $p<.001$. Students who received conventional training completed three of the four tasks more quickly than those who were trained with the simulator. Performance was significantly faster for the conventionally trained group on the starter motor remove and replace task, $t(38) = 2.10$, $p<.05$; the oil pump failure (organizational task), $t(38) = 4.07$, $p.<001$); and the electrical system inspection task, $t(38) = 4.01$, $p<.001$. (See Figure 4.)

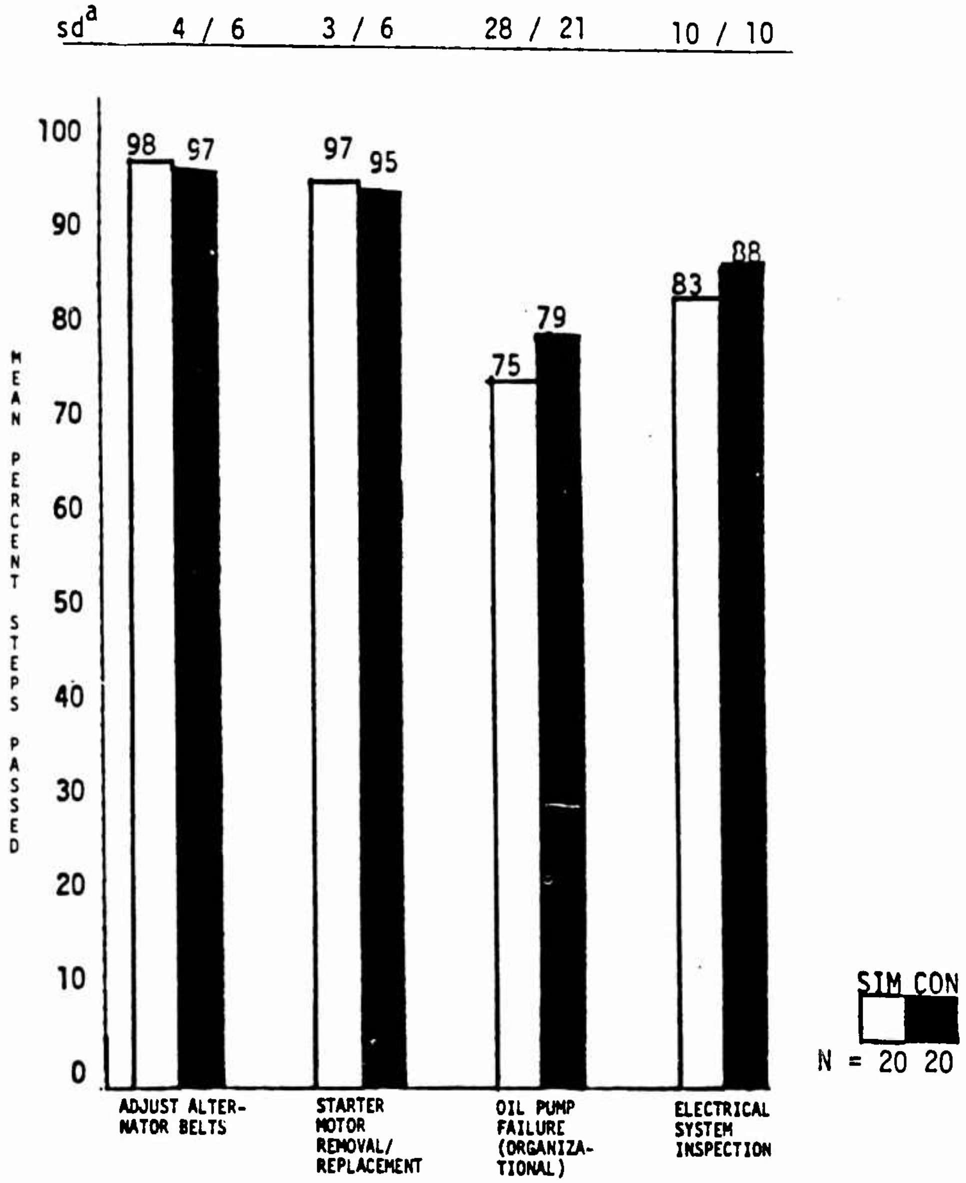
Data Collector Interventions. An overall t-test across all tasks revealed that conventionally trained students required significantly fewer data collector interventions than did simulator-trained students, $t(38) = 3.18$, $p<.005$. Subsequent t-tests indicated that this difference was almost totally due to the electrical system inspection task, $t(38) = 3.13$, $p<.01$. (See Figure 5).

Reclustered Tasks - Percent Steps Passed. Analysis of performance in terms of percent steps passed for the reclustered tasks revealed that students trained conventionally passed more steps than students trained on the simulator for the control actuation task, $t(38) = 2.76$, $p<.01$. (See Figure 6.) No other reclustered task data were significant for the percent steps passed variable.

Reclustered Tasks - Data Collector Interventions. Significant differences between the two groups of 63B30 students appeared in two of the six reclustered tasks. Significantly more instructor interventions occurred for students trained on the simulator than for students trained conventionally for the hook-up task, $t(38) = 2.45$, $p<.05$; and for the control actuation task, $t(38) = 3.02$, $p<.01$. (See Figure 7.)

Discussion

In all cases where significant differences between the two groups were detected, the performance of the conventionally trained students was superior to that of the simulator-trained students. Many of these differences between the two training conditions may be the result of a failure to include certain



SIM = Simulator-trained group
CON = Conventionally trained group

[a]sd = Standard deviation

Figure 3. Mean percent steps passed by 63B30 students.

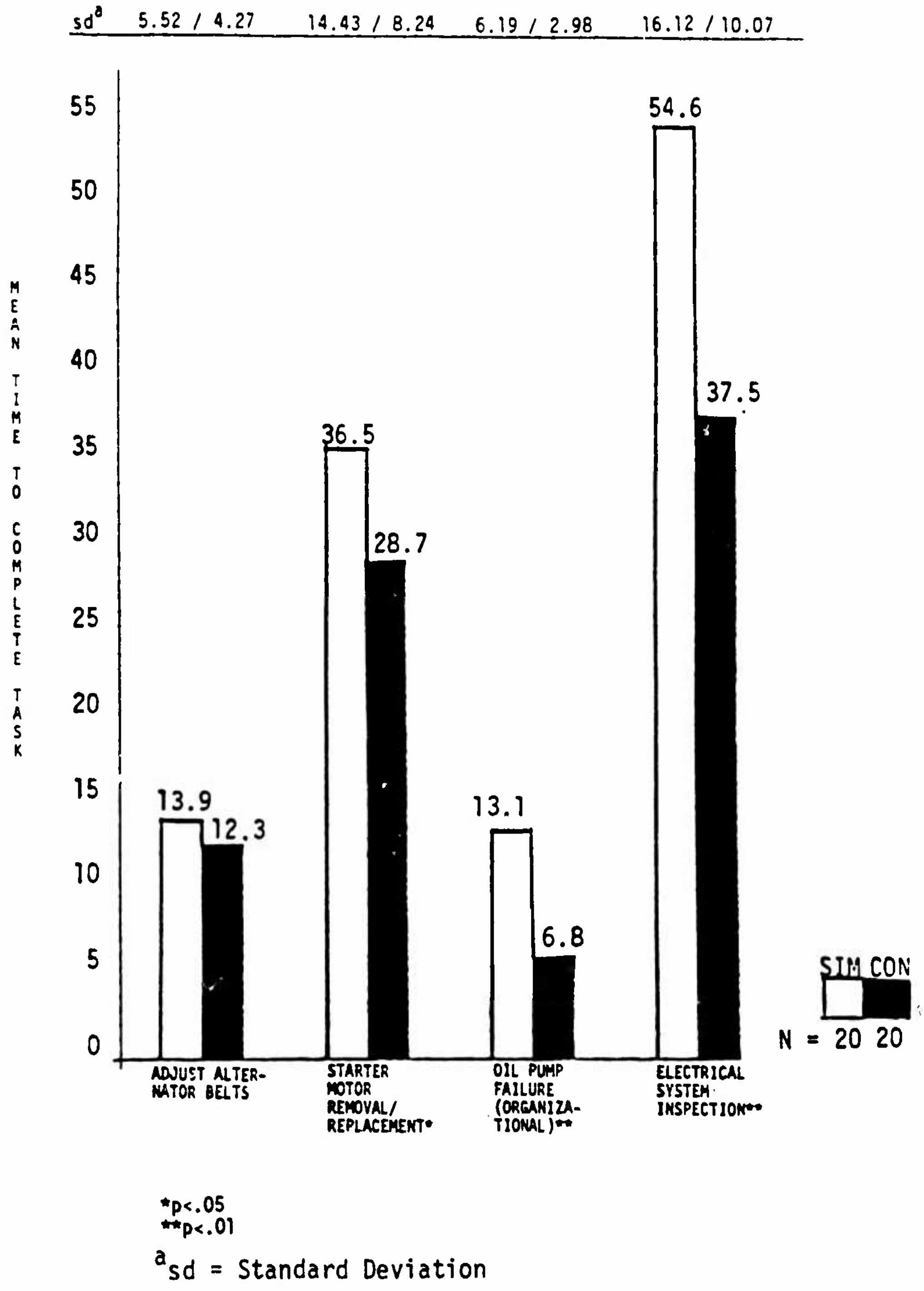
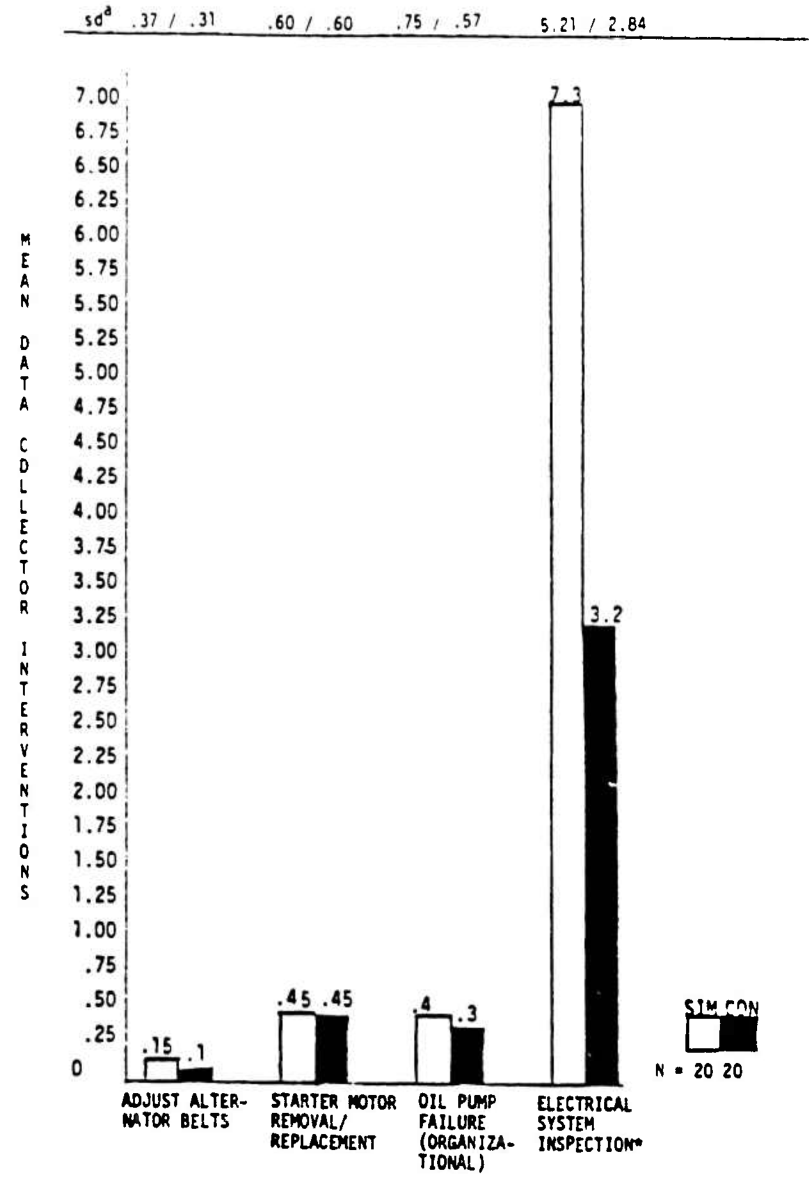


Figure 4. Mean time to complete task for 63B30 students (minutes).



*p<.01

[a]sd = Standard Deviation

Figure 5. Mean data collector interventions for 63B30 students.

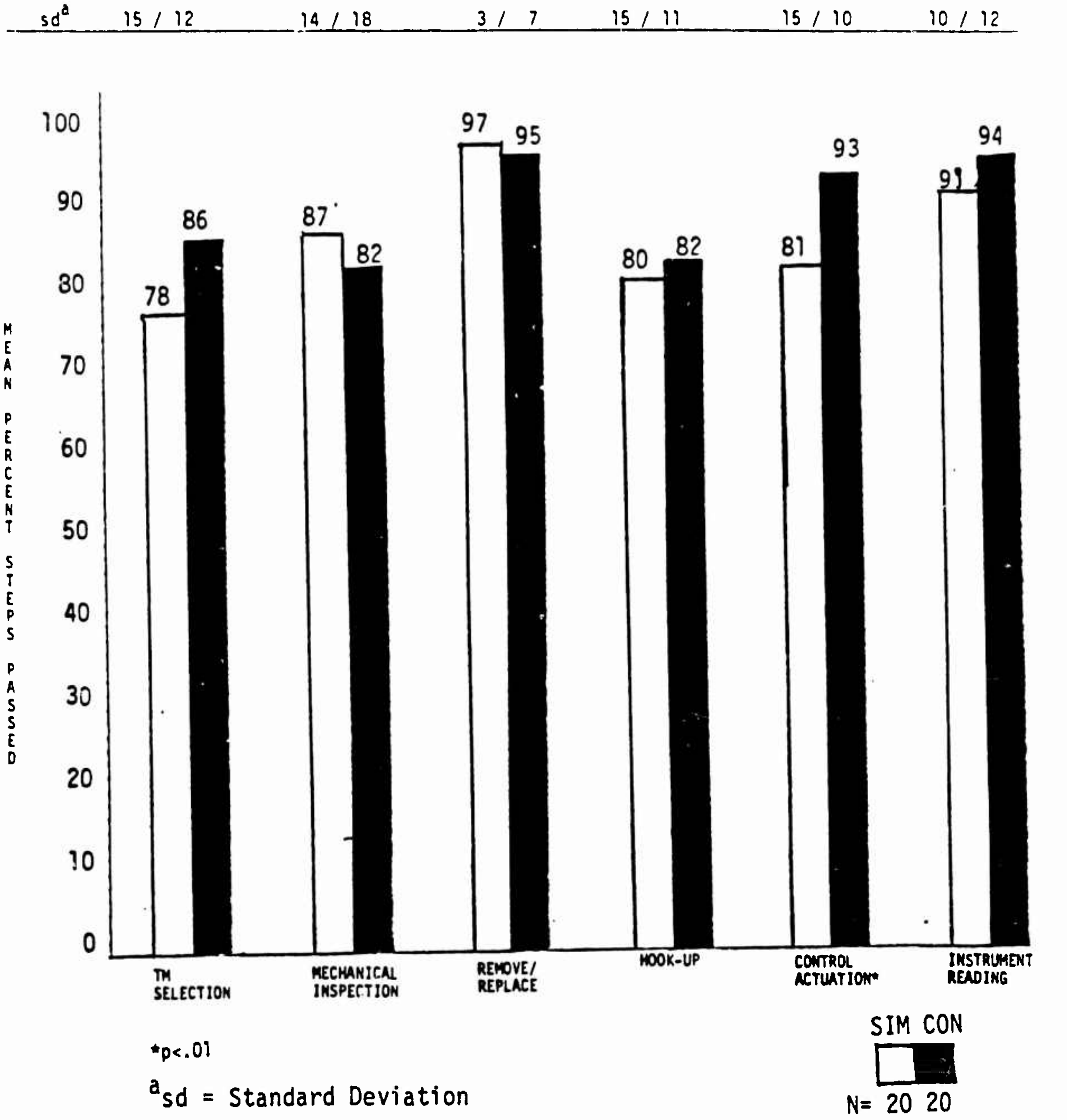
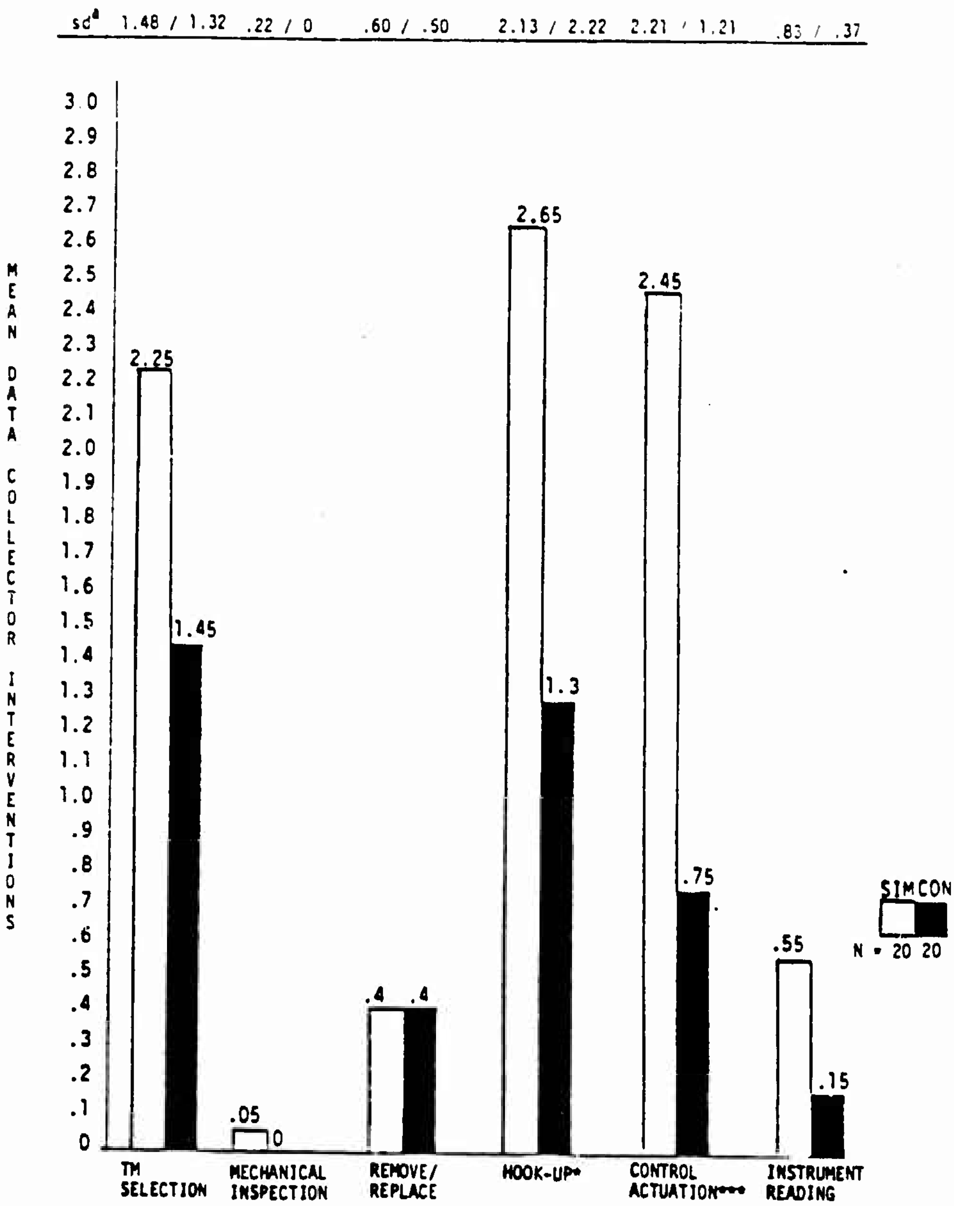


Figure 6. Mean percent steps passed by 63B30 students for reclustered tasks.



*p<.05
**p<.01
[a]sd = Standard Deviation

Figure 7. Mean data collector interventions for 63B30 students for reclustered tasks.

courseware and hardware in the Seville/Burtek device. For example, the curriculum supporting the Seville/Burtek device trained students to use the STE/ICE (i.e., electronic testing) equipment when troubleshooting, but it did not train them to set-up and check-out this equipment. Conventionally trained students, however, are required to set-up, check-out, and use this equipment to troubleshoot malfunctions during training. This difference in curriculum between the two training conditions may be the reason why simulator-trained student performance was inferior to conventionally trained student performance for the electrical system inspection task (which involves the use of STE/ICE) in terms of time to complete task and data collector interventions. This hypothesis is supported by the fact that conventionally trained students exhibited performance that was superior to simulator-trained students in terms of percent steps passed for the control actuation reclustered task, and in terms of data collector interventions for the control actuation reclustered task and the hook-up reclustered task since set-up and check-out of STE/ICE requires extensive hook-up and control actuation activities.

Students who were trained to remove/replace the starter motor on the curriculum supporting the Seville/Burtek simulator performed this task on a 3-D module that provides easy access to the starter motor. Students who were trained to perform this task on operational equipment, however, must learn to maneuver the starter motor around various obstacles in the engine compartment (i.e., the propeller shaft and the M809 vehicle frame). Although the simulator-trained students performed as well as the conventionally trained students in terms of the steps required to complete this task, they experienced considerable difficulty maneuvering the starter motor on the operational equipment. This problem is reflected in the data that indicate inferior performance by the simulator-trained students in terms of time to complete this task.

Inferior performance by the simulator-trained students in terms of the time required to complete the oil pump failure (organizational level) task may also be due to a failure to include certain hardware in the Seville/Burtek device. This task requires students to identify and troubleshoot an oil line. Although this oil line is represented on the simulator, the operational equipment is composed of other oil lines and related components that are not represented on the simulator. Thus, when simulator-trained students attempt to perform this task on the operational equipment, they spend a considerable amount of time attempting to identify the relevant oil line.

Generally speaking, the 3-D module of the Seville/Burtek device is a high fidelity representation of a Cummins NHC-250 diesel engine. Students trained on the curriculum associated with the device performed nearly as well as students trained on operational equipment, as indicated by the high E/C ratios and C/E ratios in Table 4. The performance of simulator-trained students may have more closely approached the level of conventionally trained students, however, if the fidelity of the 3-D device had been higher or if simulator-trained students had been allowed to familiarize themselves with the operational equipment prior to the performance test. If the device is designed to completely replace operational equipment, then it would appear that a very high level of physical and functional fidelity would be

required for simulator-trained student performance to equal conventionally trained student performance. On the other hand, if the device is designed to be used in conjunction with operational equipment, then the existing level of fidelity found in the device (or perhaps even less fidelity) appears appropriate.

Experiment 2

Experiment 2 also addressed a transfer-of-training assessment of the Seville/Burtek device at APG. In this experiment, students from MOS 63W10 were trained on five subtasks of an oil pump failure task on the M809 vehicle using either the simulator-based or conventional training methods. The students were then tested on their ability to perform these subtasks on operational equipment.

The original experimental design called for the exclusive use of 63W10 students in the evaluation of the Seville/Burtek simulator. This plan was modified when it became apparent that the simulator addressed primarily tasks currently taught in the 63B30 MOS. (Experiment 1 addressed these tasks.)

During government acceptance of the Seville/Burtek device, it was discovered that the simulator 3-D module did not simulate the same engine as was used in the 63W10 MOS. Therefore, in order to conduct a transfer-of-training study of this simulator in the MOS for which it was designed, using Advanced Individual Training (i.e., "10 level") students, Army School personnel developed a unique curriculum using conventional instructional methods to serve as a comparison course for students trained on the simulator. This course was limited to a single oil pump removel/replacement task which was composed of five subtasks. Practical constraints involved in developing an entirely new conventional training curriculum precluded the possibility of including more than one task in the simulator evaluation effort. The uniquely designed conventional curriculum essentially involved substitution of an M809 vehicle oil pump removal/replacement task for a similar task performed on a smaller wheeled vehicle.

Method

Subjects. Forty-one students from the 63W10 MOS (Direct Support Vehicle Repairman) served as subjects in the second experiment. All students had recently completed basic training and were receiving advanced individual training (AIT). The mean age of the trainees was 19 years, and they ranged in grade from E-1 to E-3. Since access to these trainees was limited for study purposes, both Regular Army and Reserve trainees were utilized in the study. Eighteen of the 20 conventionally trained students were Reserve trainees, while all 21 experimentally trained students were Regular Army soldiers. This, of course, introduced a possible confounding factor in the study design. The 63W10 course at APG was the first formal exposure to Army equipment for all students.

Design. The design for Experiment 2 is presented in Figure 8. Twenty students received conventional training on an actual equipment trainer and 21 students were trained using the curriculum associated with the

Seville/Burtek simulator. All students were tested on operational equipment (an M809 truck). As was true in Experiment 1, new data collection forms were developed and tested with help from School Subject Matter Experts (SMEs). These forms allowed the data collector to record the same type of information that was recorded in Experiment 1. The original Army School performance tests, as well as the revised versions of these tests are presented in Appendix B.

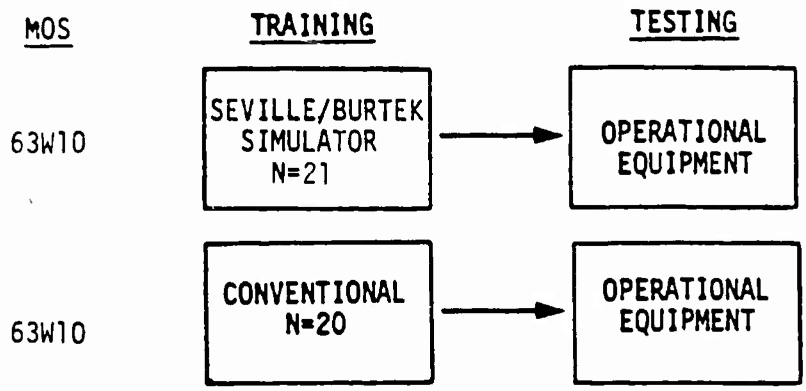


Figure 8. Design of Experiment 2.

Qualitative data recorded during Experiment 2 are presented and discussed separately in Volume III of this report.

Apparatus. The following equipment was used in Experiment 2:

- Seville/Burtek simulator
- M809 series 5-ton truck employing a Cummins NHC-250 diesel engine
- Technical manuals for the M809 series vehicle
- Army Form DA 2404 (equipment inspection and maintenance worksheet)
- General mechanic's automotive tool kit
- Two additional oversized vehicles
- An oil pressure gauge which was known to function properly

Procedure. Experiment 2 was conducted in a similar fashion to Experiment 1. Students were trained in groups of two and were individually tested by the data collector. The mean training time was 2.5 hours for simulator-trained students and 2 hours for conventionally trained students. Time required to complete testing ranged from 45 minutes to 90 minutes.

Students trained on the curriculum supporting the Seville/Burtek simulator participated in the following lessons:

- NHC-1: Introduction to NHC-250 diesel engine simulator
- NHC-2: Introduction to NHC-250 diesel engine
- NHC-16: Introduction to troubleshooting
- NHC-17: Troubleshoot and repair engine (oil pump failure)

Conventionally trained students participated in the uniquely designed curriculum discussed previously for the same tasks. Students were briefed by an instructor about the M809 truck and the NHC-250 diesel engine. The instructor helped students identify the location and function of oil lines, the oil pressure gauge in the truck cab, and other engine components. Under the supervision of the instructor, students used TMs and various tools in order to perform the troubleshooting task. The instructor queried students and guided their actions as they performed the troubleshooting task.

The number of simulator-based lessons for which students received training was limited for the same reasons that limited training in Experiment 1. Students were tested on a task which involved assessment of their ability to troubleshoot, remove, and replace an oil pump. This task consisted of five sequential subtasks:

- Perform organizational troubleshooting
- Perform direct support troubleshooting
- Remove the oil pump filter
- Remove the oil pump
- Replace the oil pump and filter

Each subtask is itself composed of a set of sequential steps.

As was true in Experiment 1, authorities at APG were reluctant to impede the flow of student progress through their regularly scheduled curriculum. Consequently, although a total of 83 63W10 students were trained on the simulator, only 21 were tested during the evaluation. All 20 of the conventionally trained students were tested.

Two instructors conducted training sessions. One instructor trained all students in the conventionally trained group, and 12 of the 20 students in the simulator-trained group. A second instructor trained the remaining eight students in the simulator-trained group.

Results

Data from Experiment 2 were analyzed in a manner similar to that used for Experiment 1. Again, E/C and C/E ratios were computed for percentage of performance test steps passed, time to complete each subtask, and number of data collector interventions required during testing. Subsequently, a series of 28 two-tailed t-tests was used to detect differences between the conventionally trained and simulator-trained groups for these variables and for percentage of performance test steps passed for reclustered tasks and for number of data collector interventions for reclustered tasks. With the exception of the hook-up cluster, the reclustered tasks consisted of those reported in Experiment 1. Hook-up activities were not required in this experiment.

As shown in Table 5, analysis of student background data revealed no significant differences between the two groups of students in terms of age, grade, and ASVAB scores.

Table 5

Characteristics of Trainees Involved in Experiment 2

Characteristic	Simulator Training	Conventional Training
Age:		
Mean	19.76	19
Standard Deviation	1.73	1.92
Grade: Range	E1-E2	E1-E3
ASVAB Scores:		
General Maintenance		
Mean	103.19	102.05
Standard Deviation	13.35	16.94
Mechanical Maintenance		
Mean	105.14	104.3
Standard Deviation	15.29	12.42
General Technical		
Mean	97.29	98.1
Standard Deviation	15.35	11.52
Electronics		
Mean	101.24	98.1
Standard Deviation	12.62	14.15

E/C and C/E Ratios. Inspection of Table 6 indicates that the percentage of steps passed by experimentally trained students was over 90% as high as the scores obtained by the conventionally trained students on three of the five subtasks performed. Mean E/C ratio for all tasks approached 90%. Only for the oil pump failure (organizational) subtask was the E/C ratio relatively low.

Table 6

E/C and C/E Ratios for 63W10 Students

Task	E/C Ratio Percent Steps Passed	C/E Ratio Time to Complete Task	C/E Ratio Data Collector Interventions
Oil pump failure (organizational)	67.57 67.57	39.58 39.58	78.95 78.95
Oil pump failure (direct support)	92.47	44.44	22.39
Oil pump filter removal	81.82	51.82	40.70
Oil pump removal	95.7	66.03	56.45
Filter/pump replacement	96.81	60	46.51
	$\bar{x}$ = 86.87	$\bar{x}$ = 52.37	$\bar{x}$ = 49

The C/E ratios for time to complete tasks indicates that the conventionally trained students performed all five subtasks faster than did the experimentally trained students. Conventionally trained students completed the five subtasks in slightly more than half of the time (approximately 52%) required by experimentally trained students. (See Table 6.)

The C/E ratios for data collector interventions indicate that conventionally trained students required fewer interventions than experimentally trained students for all five subtasks. Conventionally trained students required slightly less than half (49%) of the interventions required by experimentally trained students.

Percent Steps Passed. An overall t-test comparing the percentage of steps passed for the two groups of students indicated that the performance of the conventionally trained students was superior to the performance of

the simulator-trained students, $t(39) = 3.22$, $p<.005$. This overall difference was accounted for by performance on two subtasks. Subsequent t-tests revealed that students who were trained conventionally exhibited a significantly higher percentage of steps passed for both the oil pump failure (organizational) subtask, $t(39) = 3.16$, $p<.001$, and the oil pump filter removal subtask, $t(39) = 2.21$, $p<.05$. These data are shown in Figure 9.

Time to Complete Task. Conventionally trained students completed their subtasks faster than simulator-trained students, $t(39) = 6.09$, $p<.0001$. Performance of conventionally trained students was significantly faster for all subtasks: the oil pump failure (organizational) subtask, $t(39) = 6.97$, $p<.001$; the oil pump failure (direct support) subtask, $t(39) = 4.11$, $p<.001$; the oil pump filter removal subtask, $t(39) = 4.79$, $p<.001$; the oil pump removal subtask, $t(39) = 3.91$, $p<.001$; and the filter pump replacement subtask, $t(39) = 4.17$, $p<.001$. Figure 10 shows these data.

Data Collector Interventions. An overall t-test revealed that conventionally trained students required fewer data collector interventions during testing than were required by the simulator-trained students, $t(39) = 2.62$, $p<.05$. This overall difference was accounted for by one subtask. Students in the 63W10 MOS who were trained on the simulator required significantly more data collector interventions than did those receiving conventional training for the oil pump failure (direct support) subtask, $t(39) = 2.65$, $p<.05$. See Figure 11 for these data.

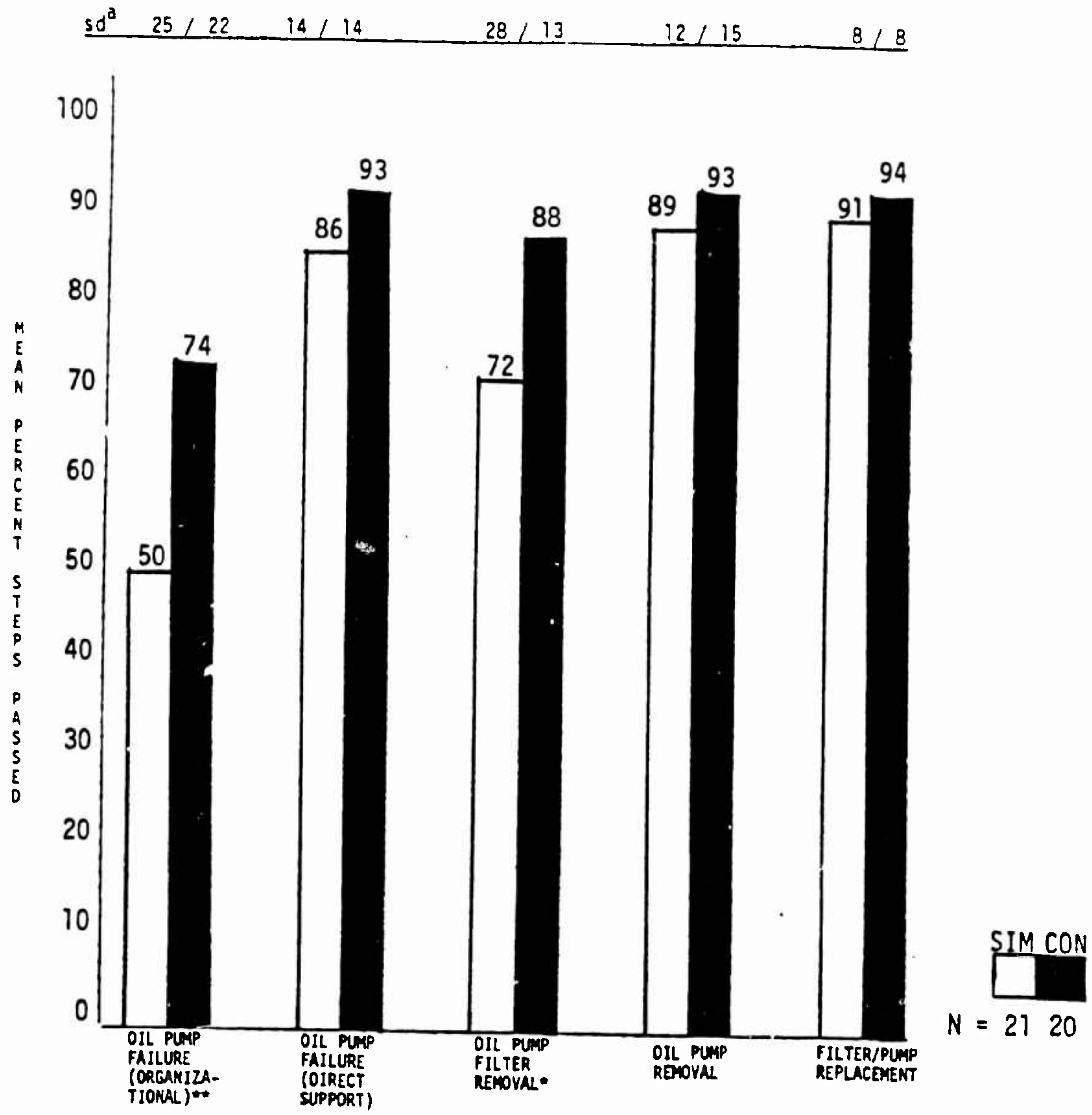
Reclustered Tasks - Percent Steps Passed. Analysis of the performance of the 63W10 students in terms of percentage of steps passed for reclustered tasks indicated that students receiving conventional training exhibited superior performance for the TM selection task, $t(39) = 2.75$, $p<.01$; for the remove/replace task, $t(39) = 3.73$, $p<.01$; and for the control actuation task, $t(39) = 2.72$, $p<.01$. Figure 12 shows these data.

Reclustered Tasks - Data Collector Interventions. Significant differences were also noted between the two groups of 63W10 students in terms of data collector interventions. Students trained on the simulator required significantly more interventions during testing than did those trained conventionally for the TM selection task, $t(39) = 2.22$, $p<.05$; and for the remove/replace task, $t(39) = 2.3$, $p<.05$. See Figure 13.

Discussion

As with Experiment 1, where significant differences between the two groups of students were detected, the students trained conventionally exhibited superior performance to that of students trained with the Seville/Burtek simulator. This was true for all five criterion measures (percent steps passed, time to complete the subtask, data collector interventions, percent steps passed for the reclustered tasks, and data collector interventions for reclustered tasks).

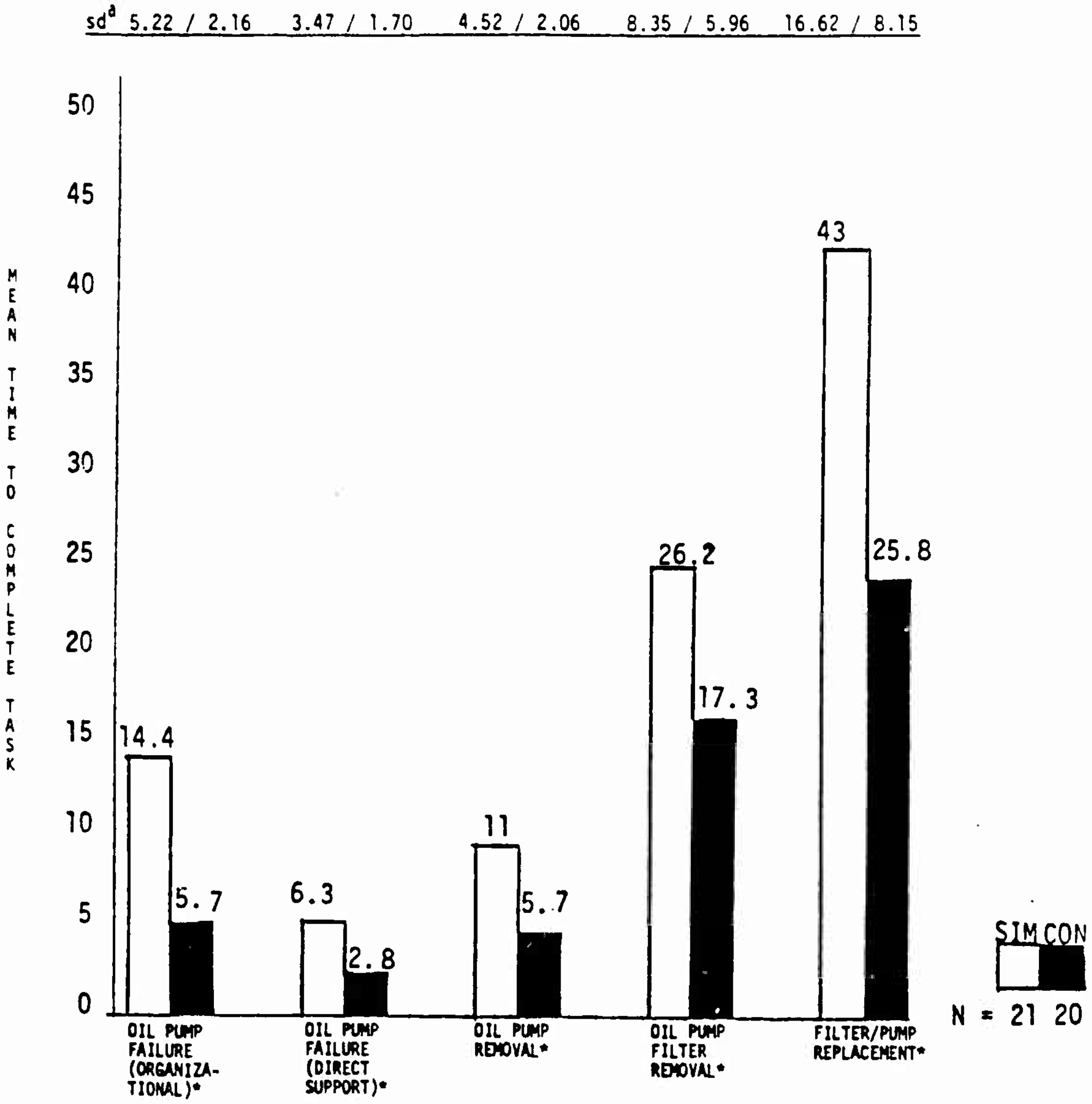
Students trained on the simulator passed fewer steps than conventionally trained students on subtasks 1 and 3. Analysis of the performance of simulator-trained students on subtask 1 revealed that they experienced



*p<.05
**p<.001

[a]sd = Standard Deviation

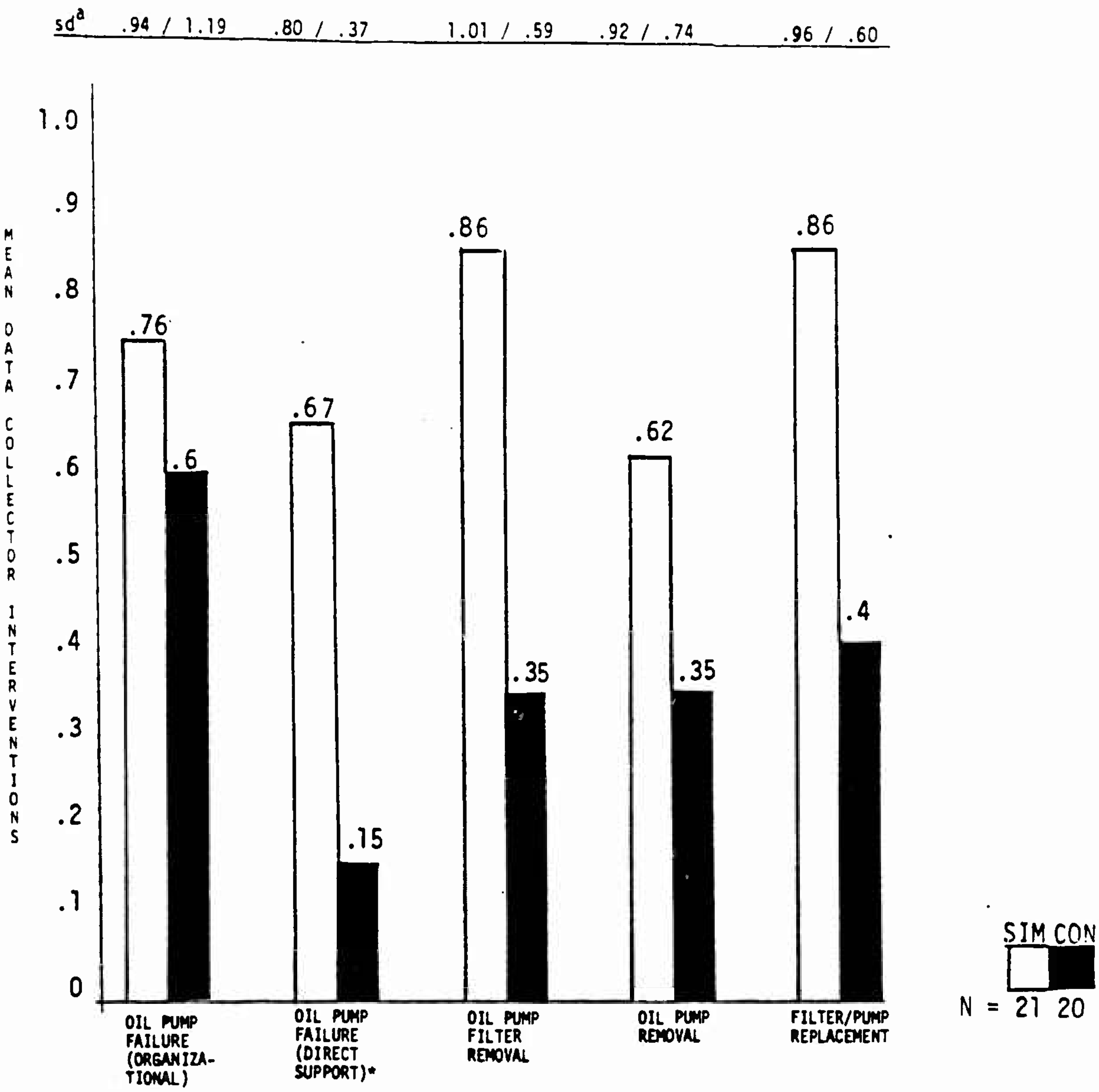
Figure 9. Mean percent steps passed by 63W10 students.



*p<.001

[a]sd = Standard Deviation

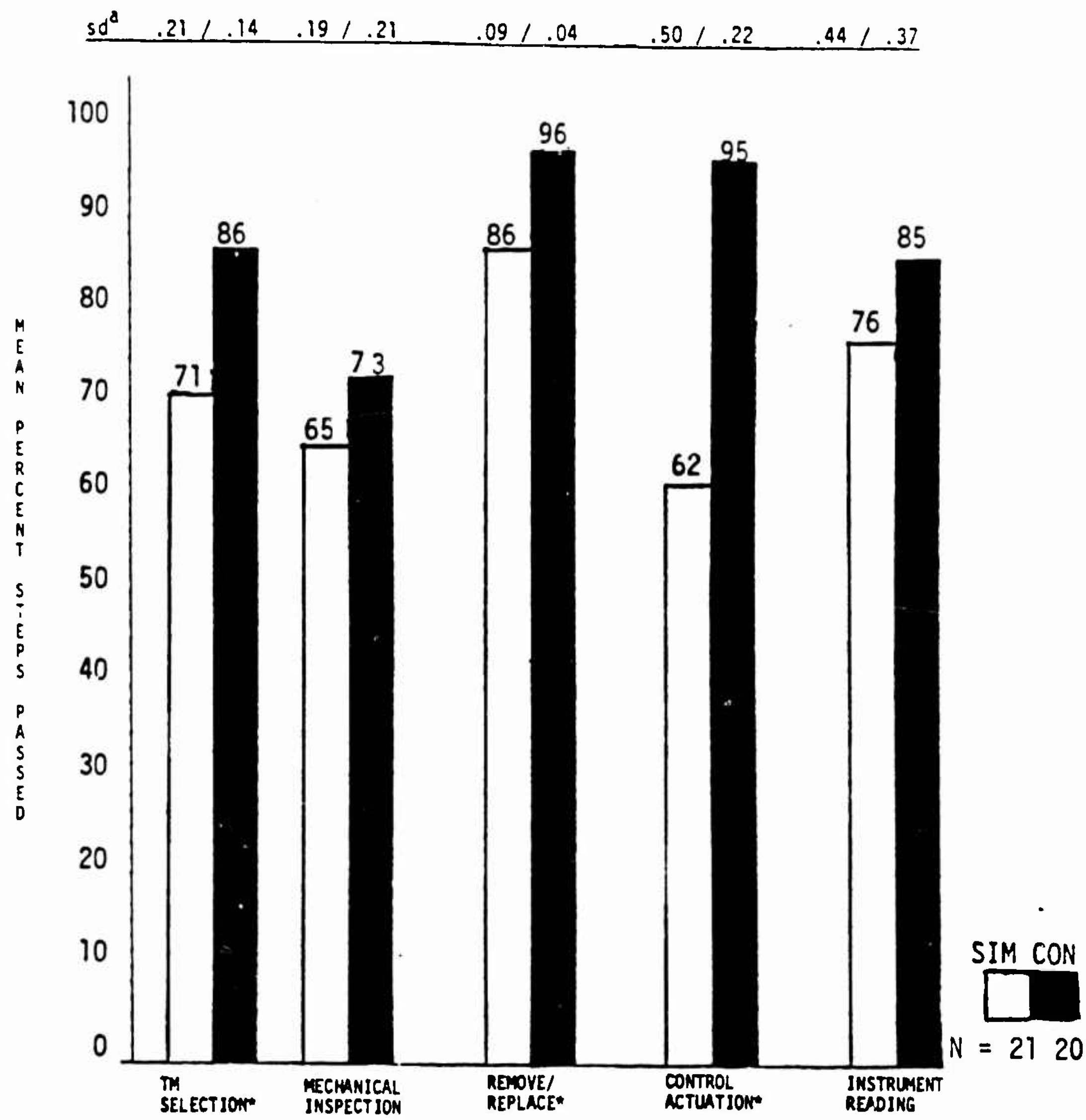
Figure 10. Mean time to complete task for 63W10 students (minutes).



*p<.05

[a]sd = Standard Deviation

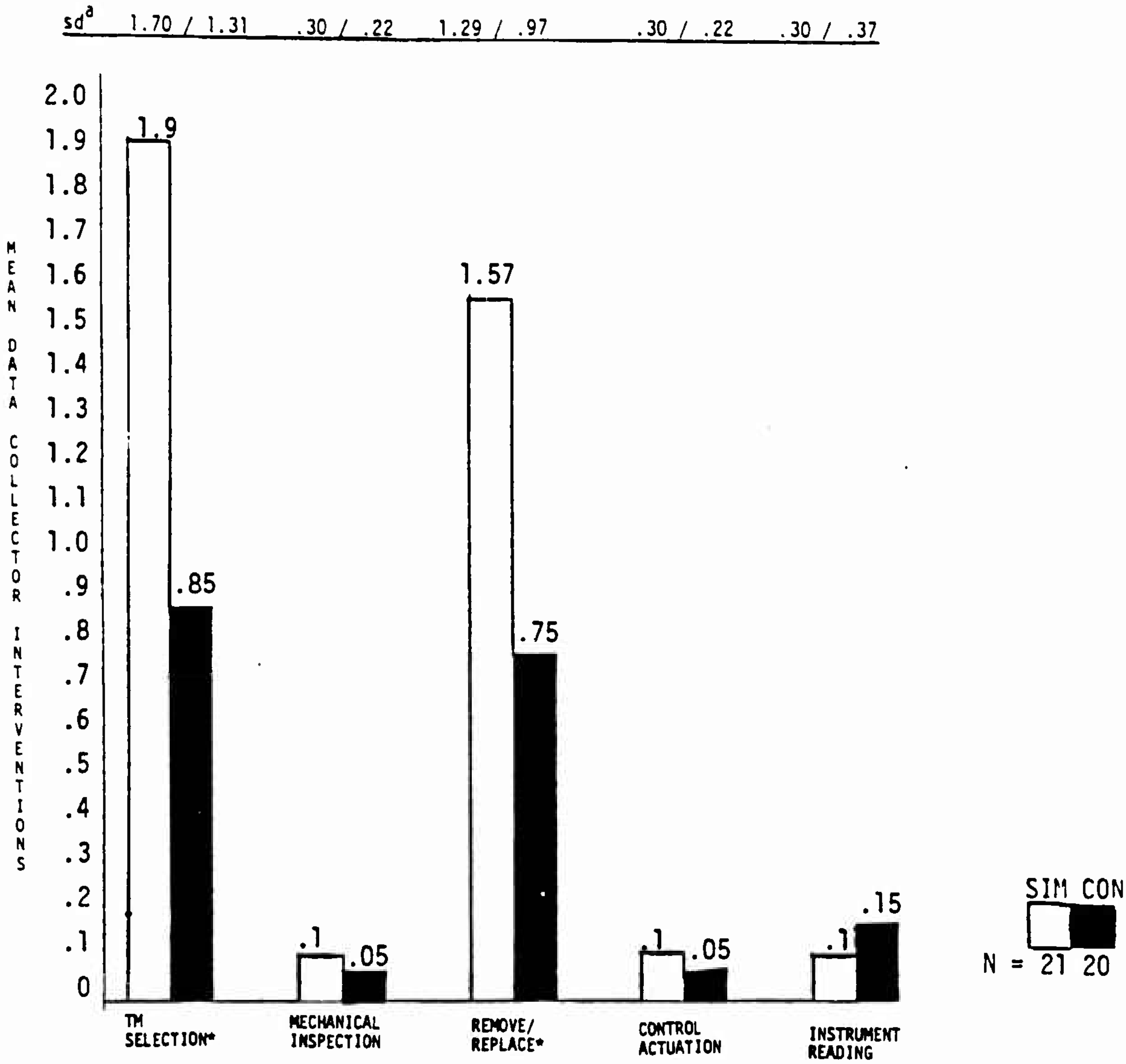
Figure 11. Mean data collector interventions for 63W10 students.



*p<.01

[a]sd = Standard Deviation

Figure 12. Mean percent steps passed by 63W10 students for reclustered tasks.



*p<.05

[a]sd = Standard Deviation

Figure 13. Mean data collector interventions for 63W10 students for reclustered tasks.

difficulties completing steps 6, 7, 8, 9, and 10 which involved remove/replace, reading TM, instrument reading, and control actuation activities. Analysis of the performance of the simulator-trained students for subtask 3 indicated that they experienced difficulties completing steps 1 and 2 which involved the use of TMs, and steps 3 and 4 which require remove/replace skills. Thus, the use of TMs and remove/replace activities seemed to give simulator-trained students the greatest difficulty. This interpretation is supported by the fact that for the reclustered tasks (which involved all five subtasks), simulator-trained students passed fewer steps than did conventionally trained students, and required more data collector interventions than did conventionally trained students for both the reclustered TM selection task and for the reclustered remove/replace task.

It seems likely that the problems in using TMs encountered by the simulator-trained students may have stemmed from the fact that the curriculum supported by the simulator did not emphasize this activity. Simulator-trained students received messages on their CRT that simply directed them to locate specific TMs, and the appropriate pages, tables, and figures within TMs. During conventional training, however, instructors spent considerable time training students in the correct use of TMs. That is, conventionally trained students were taught to use the table of contents and to follow the flow of logic in the TM from one page to the next. If this type of information had been presented to simulator-trained students on the CRT, they may have experienced fewer problems with tasks requiring TM usage.

The problems associated with remove/replace tasks encountered by simulator-trained students may have been due to the fact that these students were tested on their ability to perform these tasks on the operational equipment without formal equipment familiarization training. Although the 3-D module of the Seville/Burtek simulator is a high fidelity representation of a diesel engine, many small differences exist between the configuration of the 3-D module and an actual engine. For example, simulator-trained students were not familiar with the location and function of engine components that were not represented on the simulator. This fact caused confusion when students first encountered the operational equipment. Further, these students did not learn how to use tools in a cramped work environment (where workspace is limited, as is the case with operational equipment). These factors seemed to adversely affect the performance of simulator-trained students when they worked on operational equipment.

Thus, although the Seville/Burtek simulator is a high fidelity representation of operational equipment, the lack of physical and functional fidelity may effectively degrade student performance. This implies that the Seville/Burtek device may be most appropriately seen as a part-task trainer. It may be appropriate to provide equipment familiarization training for simulator-trained students. Alternatively, training for remove/replace tasks may be accomplished most effectively on operational equipment. If this is the case, the high fidelity of the 3-D module associated with the Seville/Burtek device (developed for remove/replace tasks) may be unnecessary.

Experiment 3

Experiment 3 concerned a transfer-of-training assessment for students trained on the Grumman device at APG. In Experiment 3, 63H30 students were trained on eight subtasks involving a defective voltage regulator on the M110 howitzer using either the simulator-based or conventional training methods. Students were then tested on their ability to perform these subtasks on the operational howitzer.

The original experimental design called for the exclusive use of 63D30 students in the evaluation of the Grumman device. However, since the student flow in the 63D30 MOS was low, students from the 63H30 MOS were necessarily incorporated into the study. This experiment reports on the study conducted using 63H30 students. Experiment 4 reports on the 63D30 study.

Method

Subjects. Twenty-two students from MOS 63H30 (Direct Support Maintenance Supervisor) participated in Experiment 3. Prerequisite MOSs for entrance to the 63H30 MOS include the following direct support/general support maintenance MOSs: 63W (Wheeled Vehicle Repairman), 63H (Track Vehicle Repairman), and 63G (Fuel and Electrical Systems Repairman). The 63H30 personnel represent second and third echelons of organizational maintenance activity. In these units, work involves such activities as component bench testing, rebuilding components, and overhauling vehicles.

Design. The design of Experiment 3 is presented in Figure 14. Twelve students received conventional training on an actual equipment trainer and 10 students were trained on the curriculum associated with the Grumman simulator. All students were tested on operational equipment (M110 howitzer). As in the previous experiments, new data collection forms were developed and tested with the help of Army School SMEs. These forms allowed for collection of data on the same variables as were measured in Experiments 1 and 2. The Army performance tests as well as revised versions used in the study for the 63H30 experiment are presented in Appendix C.

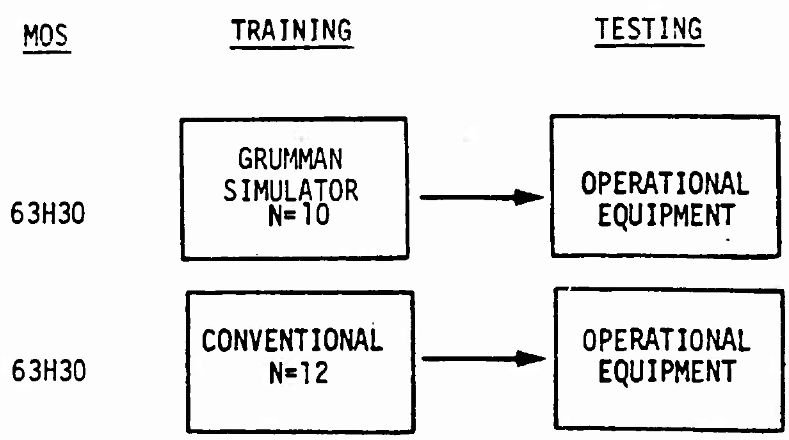


Figure 14. Design of Experiment 3.

Qualitative data recorded during Experiment 3 are presented and discussed in Volume III of this report.

Apparatus. The following equipment was used in Experiment 3:

- o Grumman simulator
- o M110A2 self-propelled 8-inch heavy howitzer
- o Technical manuals for the M110A2 howitzer
- o STE/ICE (Simplified Test Equipment/ Internal Combustion Engine)
- o Army Form DA 2404 (equipment inspection and maintenance worksheet)
- o General mechanic's automotive tool kit
- o A voltage regulator for the M110A2 which was known to function properly

Procedure. The procedures employed in Experiment 3 were similar to those used in Experiments 1 and 2. Students were trained in groups of two and were individually tested. The mean training time was 2.5 hours for the simulator-trained group and 2 hours for the conventionally trained group. The mean time required for the testing sessions was 2 hours for both simulator-trained and conventionally trained students.

Students trained on the simulator participated in the following lessons in the Grumman curriculum:

- o Segment 0: Introduction, part 1
- o Segment 1: Introduction, part 2
- o Segment 2: VTM set-up and check-out tutorial (The VTM is a component of the STE/ICE equipment testing set.)
- o Segment 3: VTM set-up and check-out exercise
- o Segment 8: Charging system problem 2 (defective voltage regulator)

The two-part introduction explains the functioning of the simulator and how it relates to the M110 howitzer. Segments 2 and 3 describe procedures for set-up and check-out of the STE/ICE equipment testing kit. Segment 8 concerns the M110 charging system and addresses symptoms associated with a defective voltage regulator.

Conventionally trained students were trained on the same tasks using the School curriculum. Conventional training procedures were similar to those described in Experiments 1 and 2.

Seventeen 63H30 students were trained on the Grumman simulator. Of these, 10 were subsequently tested using the performance tests associated with this study. Student attrition, school requirements, and a variety of other factors prevented inclusion of all simulator-trained students in the transfer-of-training study sample. Thirteen 63H30 students received conventional training; 12 of these students were subsequently tested and included in the study. One instructor conducted training sessions for the conventionally trained students; four other instructors trained students on the simulator-based curriculum.

Ordnance School representatives indicated that it would require excessive time for conventionally trained students to be trained on all tasks which were addressed by the training curriculum associated with the Grumman device. For example, in order to provide conventional training that was comparable to several lessons taught on the simulator, removal and replacement of the engine and transmission assemblies would have been required. Removal and replacement of these assemblies is very time consuming and, therefore, infrequently performed by School personnel. Thus, students trained on the simulator received instruction on introductory lessons, and on troubleshooting, but not on removal and replacement of major assemblies.

Although only one task in the 63H30 experiment was chosen by the Ordnance School for inclusion in the transfer-of-training study, that task was composed of the following eight subtasks:

1. Confirm malfunction
2. Troubleshoot electrical system
3. Perform VTM hook-up and check-out
4. Perform generator regulator charging circuit test
5. Troubleshoot charging circuit
6. Remove/replace generator voltage regulator
7. Perform VTM hook-up and check-out
8. Perform generator regulator charging circuit test

In this task, although the last two subtasks appear identical to subtasks 3 and 4, the final two subtasks merely require the student to inform the instructor of appropriate maintenance actions, whereas the student must actually perform these steps in subtasks 3 and 4.

Test procedures followed during the evaluation of the Grumman device were similar to those followed during the evaluation of the Seville/Burtek device:

- All students were tested individually.
- All testing was conducted by the SAI data collector.
- Testing was conducted within 24 hours after training had been completed.
- Whenever possible, testing was completed in a single session.

Results

An analysis of student background data was conducted to determine if significant differences existed between the two groups of students prior to the start of training. Table 7 shows these data. Two-tailed Mann-Whitney U tests revealed no statistically significant differences between the two training conditions in terms of age, grade, or ASVAB scores (general maintenance, mechanical maintenance, general technical, and electronic).[4] Analysis of ASVAB score data was, unfortunately, limited to approximately one-half of the sample due to the unavailability of such data in School records.

E/C and C/E ratios were computed for percentage of performance test steps passed, time to complete each subtask, and number of data collector interventions required during testing. Subsequently, nonparametric statistical tests were used to assess between-group differences. A series of 39 two-tailed Mann-Whitney U tests was conducted to investigate differences between the simulator and conventional training conditions. Data were analyzed on the following measures in Experiment 3: percentage of performance test steps passed, time to complete each subtask, number of data collector interventions required during testing, percentage of performance test steps passed for the reclustered tasks (tasks were reclustered into the same categories as were reported in Experiment 1), and number of data collector interventions required during performance of the reclustered tasks.

E/C and C/E Ratios. Inspection of Table 8 reveals that the E/C ratio measure for percentage of steps passed was greater than 90 for seven of the eight tasks performed by 63H30 students (and, in fact, was greater than 100 for three of the eight tasks).

The C/E ratio for time to complete task exceeded 80 for seven of the eight tasks performed by 63H30 students and exceeded 100 for three of these tasks. The mean C/E ratio for time to complete task was greater than 85.

[4] Mann-Whitney U tests were employed as the nonparametric statistic of choice due to the small sample sizes available in the treatment groups.

Table 7

Characteristics of Trainees Involved in Experiment 3

Characteristic	Simulator Training	Conventional Training
Age:		
Mean	32.7	28.18
Standard Deviation	4.57	4.42
Grade: Range	E5-E8	E5-E7
ASVAB Scores:		
General Maintenance		
Mean	94.67	102.33
Standard Deviation	22.05	11.83
Mechanical Maintenance		
Mean	112.17	107.33
Standard Deviation	11.69	12.06
General Technical		
Mean	108.83	98.75
Standard Deviation	10.89	10.74
Electronics		
Mean	104.33	100.11
Standard Deviation	16.77	10.82

Table 8

E/C and C/E Ratios for 63H30 Students

Task	E/C Ratio Percent Steps Passed	C/E Ratio Time to Complete Task	C/E Ratio Data Collector Interventions
Confirm malfunction	90.43	113.43	40
Troubleshoot electrical system	75.51	63.24	-[a]
VTM hook-up and check-out	93.62	103.16	52.63
Charging circuit test	93.62	94.49	75
Troubleshoot charging circuit	103.13	97.18	163.64
Remove/replace voltage regulator	110.98	85.71	325
VTM hook-up and check-out	100	146.15	216.67
Charging circuit test	93.62	84.51	45
	$\bar{x}$ = 95.07	$\bar{x}$ = 85.59	$\bar{x}$ = 91.75[b]

[a]Not applicable (conventional group required no data collector interventions)

[b]Includes data for troubleshoot electrical system subtask

Conventional/experimental ratio scores for data collector interventions exceeded 100 for three of the eight subtasks. The mean C/E ratio for data collector interventions exceeded 90.

Percent Steps Passed. An overall U-test between training groups on all measures revealed no significant differences among performance test results. Subsequent U-tests by subtask indicated that simulator-trained students scored higher on the percent steps passed measure than did conventionally trained students for the remove/replace voltage regulator subtask. For the troubleshoot electrical system subtask, however, conventionally trained students performed better ($U = 24$, $p<.05$). For the remaining six subtasks, no significant differences occurred across training groups. Figure 15 shows these data.

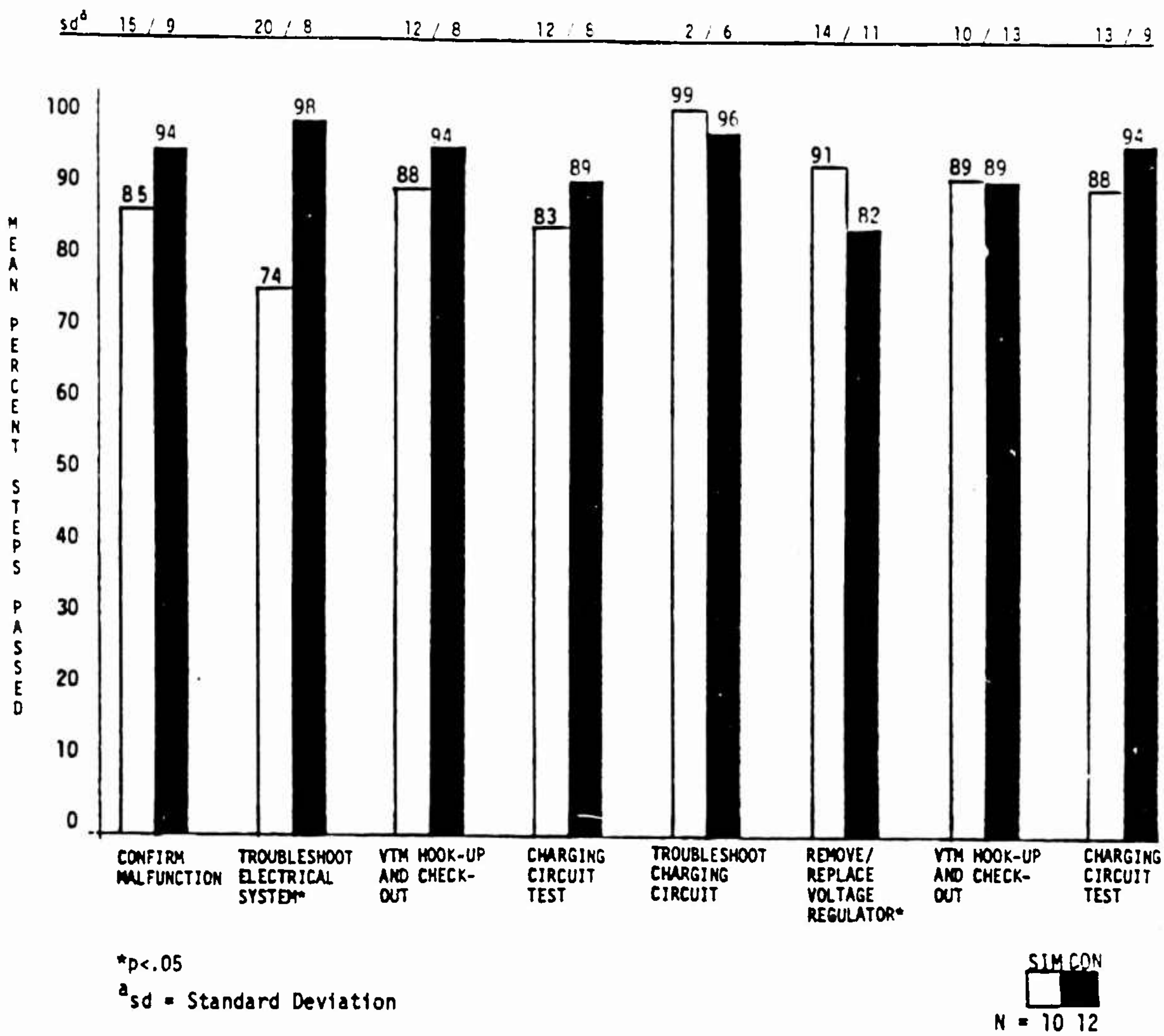


Figure 15. Mean percent steps passed by 63H30 students.

Time to Complete Task. Although an overall U-test revealed no significant differences between the two groups on the time to complete measures; subsequent U-tests by subtask revealed that conventionally trained students performed the troubleshoot electrical system subtask significantly faster than did simulator-trained students, $U = 25$, $p<.05$. (See Figure 16.)

Data Collector Interventions. An overall U-test indicated that simulator-trained and conventionally trained groups did not differ in terms of numbers of data collector interventions required during the performance test. Independent Mann-Whitney U-tests conducted for each of the eight tasks indicated that conventionally trained 63H30 students required fewer data collector interventions than did simulator-trained students for the troubleshoot electrical system task ($U = 12$, $p<.01$) while simulator-trained students required fewer data collector interventions than did conventionally trained students for the remove/replace voltage regulator task ($U = 26$, $p<.05$). Figure 17 presents these data.[5]

Reclustered Tasks - Percent Steps Passed. As in the first two experiments, tasks in Experiment 3 were reclustered into more homogeneous skills and knowledge classifications in order to gain a better understanding of the relative effectiveness of simulator and conventional training. The tasks which emerged from the reclustering effort were identical to the tasks which emerged from the reclustering of the MOS 63W10 and MOS 63B30 tasks (i.e., TM selection, mechanical inspection, remove/replace, control actuation, instrument reading, and hook-up).

As shown in Figure 18, Mann-Whitney U-testing indicated that conventionally trained 63H30 students exhibited a significantly greater percentage of steps passed for the reclustered mechanical inspection task, $U = 18$, $p<.05$, than did simulator-trained students. Similar results occurred for the reclustered instrument reading task, $U = 24$, $p<.05$.

Reclustered Tasks - Data Collector Interventions. Conventionally trained 63H30 students also required significantly fewer data collector interventions than did their simulator-trained counterparts for the reclustered mechanical inspection task, $U = 18$, $p<.05$. Figure 19 presents these data.

Discussion

Analysis of the E/C and C/E ratios in Table 8 indicates that simulator-trained students performed nearly as well as conventionally trained students.

[5]Although several comparisons of interest in Experiments 3 and 4 (involving data collector interventions) resulted in a high percentage of tied scores, Siegel (1956) has suggested that corrections for tied scores are appropriate only in large sample cases; therefore, corrections for ties were not used. Statistical tests involving data collector interventions, thus, are conservative (i.e., may not detect significant differences between groups which may exist if less conservative tests were used).

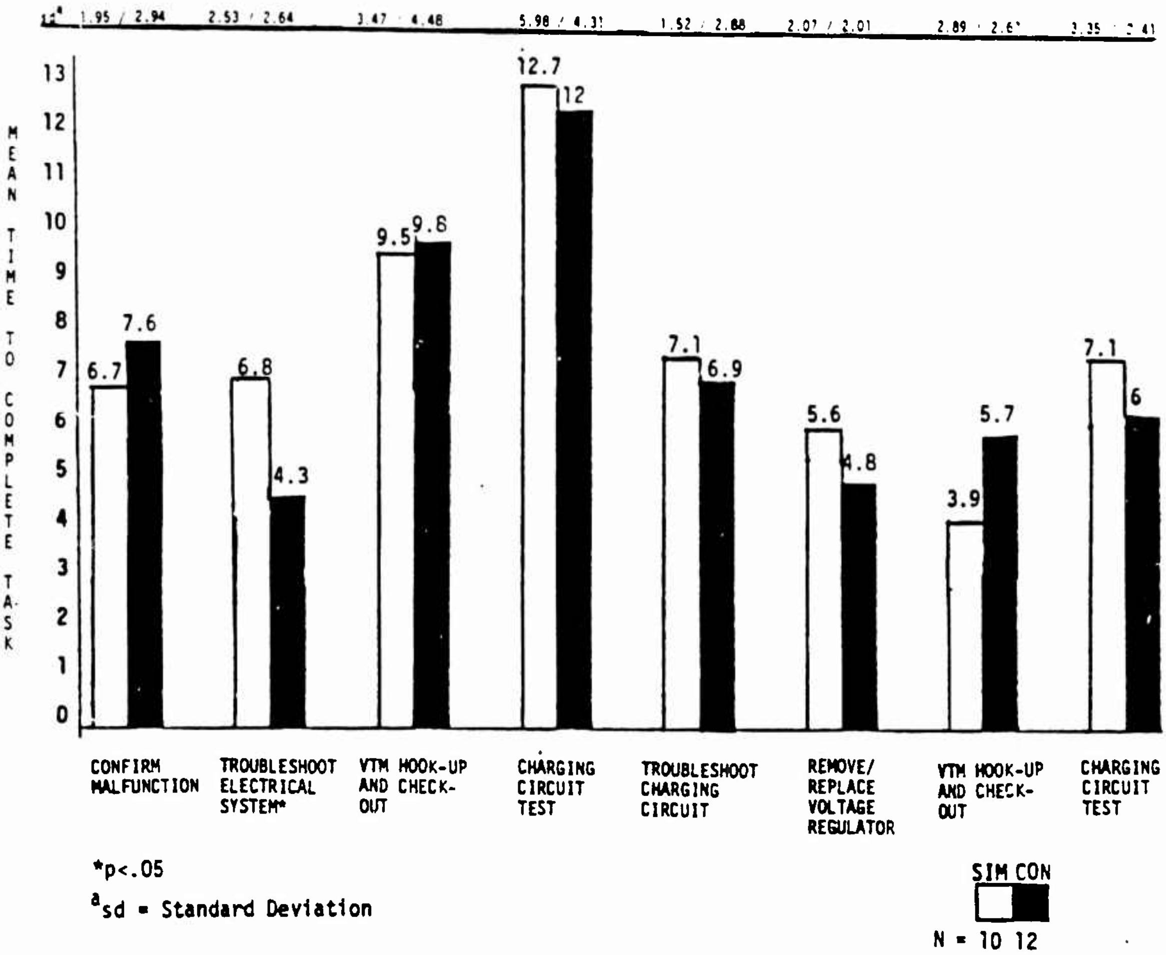


Figure 16. Mean time to complete task for 63H30 students (minutes).

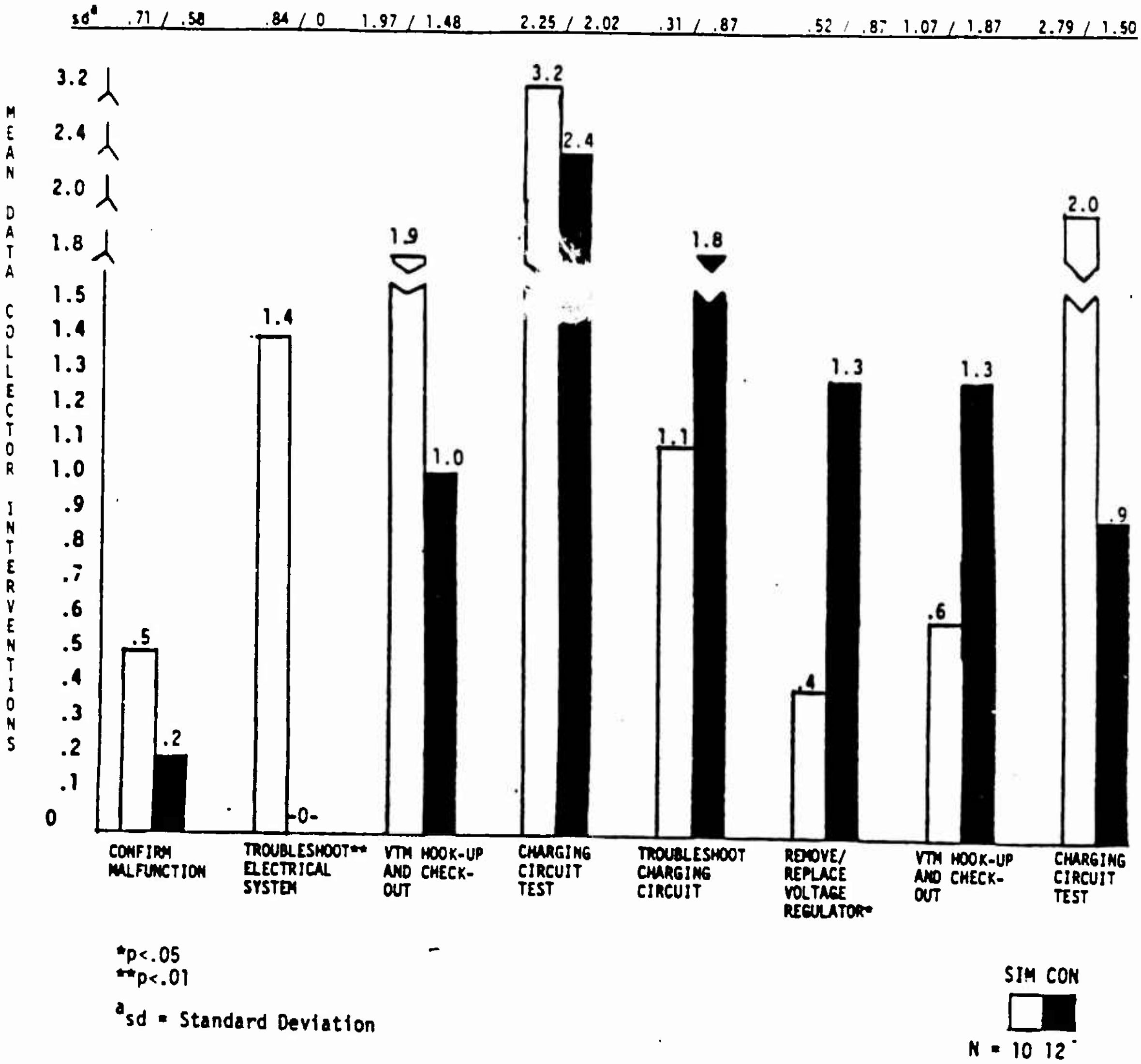
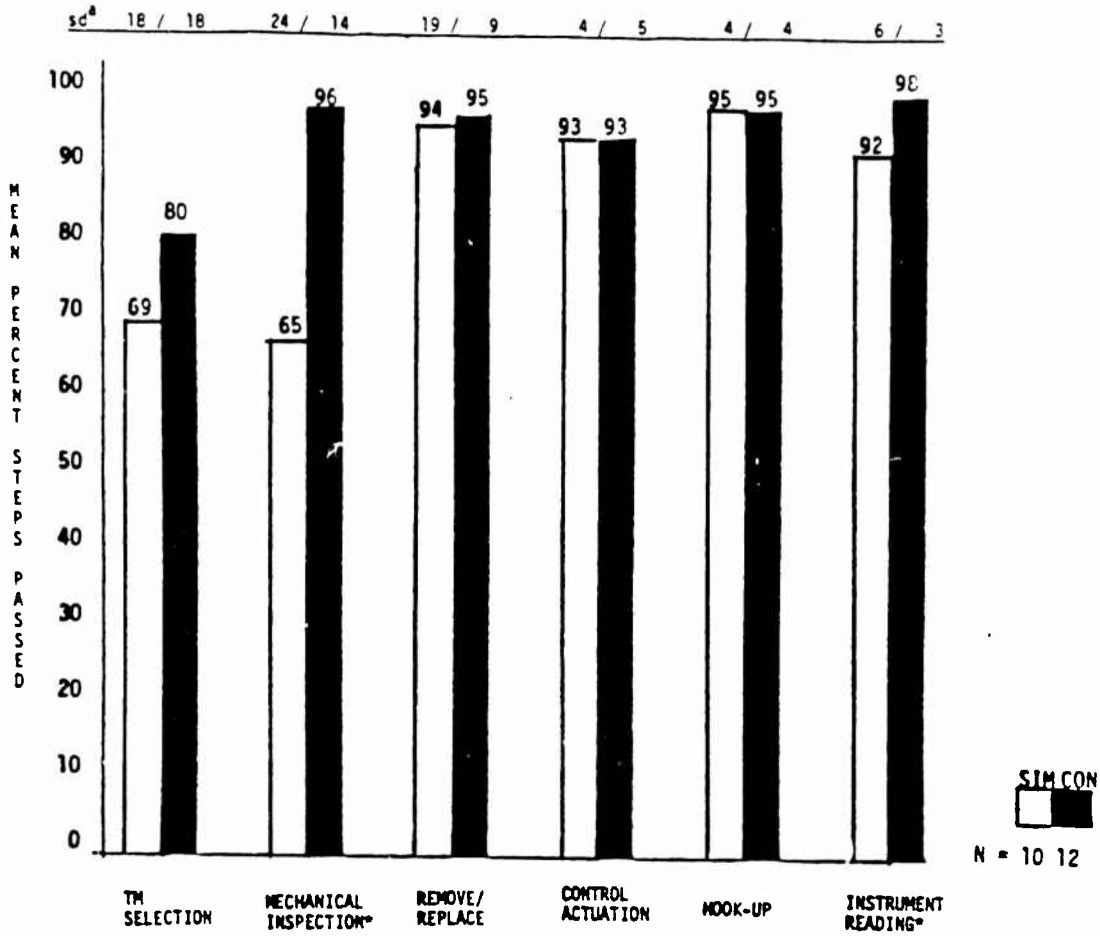


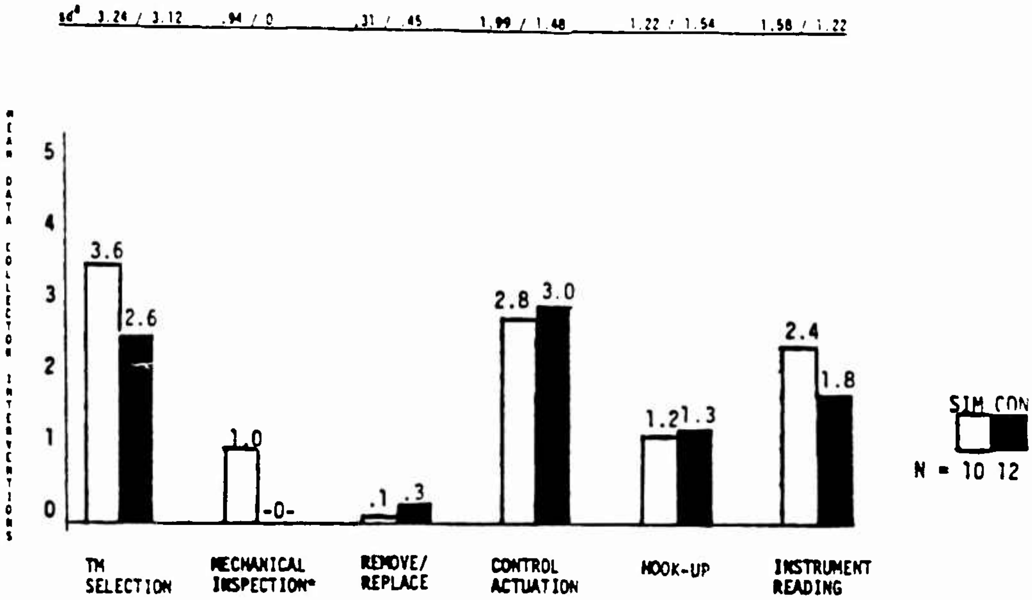
Figure 17. Mean data collector interventions for 63H30 students.



*p<.05

[a]sd = Standard Deviation

Figure 18. Mean percent steps passed by 63H30 students for reclustered tasks.



*p<.05

[a]sd = Standard Deviation

Figure 19. Mean data collector interventions for 63H30 students for reclustered tasks.

The mean E/C ratio for percentage of performance steps passed and the mean C/E ratio for data collector interventions exceeded 90, while the mean C/E ratio for time to complete task exceeded 85. In Experiment 3, conventionally trained 63H30 students performed better than did simulator-trained students for subtask 2 (troubleshoot electrical system) on the percentage of steps passed, time to complete task, and data collector intervention measures. Subsequent analysis of subtask 2 indicated that simulator-trained students committed more errors than did conventionally trained students for steps 5, 6, and 7 (which involve checking various ground leads and straps for bad connections). It seems likely that the unique configuration of the Grumman simulator may have been responsible for this difference. Although the Grumman device provides a simulation of the relevant ground leads, they (as well as other components) are actually laid out on a table. Thus, the simulator does not provide detailed information concerning the location of these leads on the body of the M110A2 vehicle. This expalanation is supported by analyses of the reclustered tasks which indicated that simulator-trained students' performance for the mechanical inspection task was inferior to the performance of conventionally trained students. The reclustered mechanical inspection task addresses skills involved in checking various components of the M110 howitzer vehicle. Simulator-trained students may have experienced difficulty in locating the components they were required to inspect. The problems students experienced because of the level of fidelity incorporated into the Grumman device are similar to the problems experienced by students who worked with the Seville/Burtek device (Experiments 1 and 2). In both cases, the physical fidelity of the 3-D module affected students' ability to identify and manipulate engine components.

Simulator-trained students performed better than did conventionally trained students for subtask 6 (remove/replace voltage regulator) on the percentage of steps passed and instructor intervention measures. Analysis of subtask 6 indicated that the difference between the two groups may have arisen from differential performance on early portions of the subtask. These portions involved such activities as TM selection, turning off the STE/ICE set, and disconnecting the battery grounds. These activities are performed immediately after the voltage regulator has been identified as the faulty component, and prior to a series of steps which involve removing and replacing the faulty component. In a sense, these steps are less important than are the primary activities of identifying and replacing the faulty voltage regulator. They may not, therefore, be emphasized as much during conventional training as they are in simulator-based training. Simulator-based training requires that students not be allowed to continue their training unless they follow procedures precisely. Conventional training may not provide such detailed attention to procedural details.

Experiment 4

Experiment 4 addresses a transfer-of-training assessment for students trained on the curriculum associated with the Grumman simulator at APG. In Experiment 4, students from the 63D30 MOS were trained on eight subtasks involving a defective voltage regulator on the M110 howitzer (the same subtasks as were used in Experiment 3) using either the training curriculum

associated with the Grumman simulator or conventional training methods. Students were then tested on their ability to perform these subtasks on the operational howitzer.

Method

Subjects. Twenty-three students in MOS 63D30 (Self-propelled Field Artillery Systems Mechanic Career Field) participated in the fourth experiment. The 63D30 students were NCOs with considerable service experience. A prerequisite for entry into the 63D30 course is prior service as an organizational systems mechanic in either MOS 45D (Self-propelled Field Artillery Turret) or in MOS 63D (Self-propelled Field Artillery Systems).

Design. The design for Experiment 4 is presented in Figure 20. Twelve students were trained on the curriculum associated with the Grumman simulator and 11 were conventionally trained.

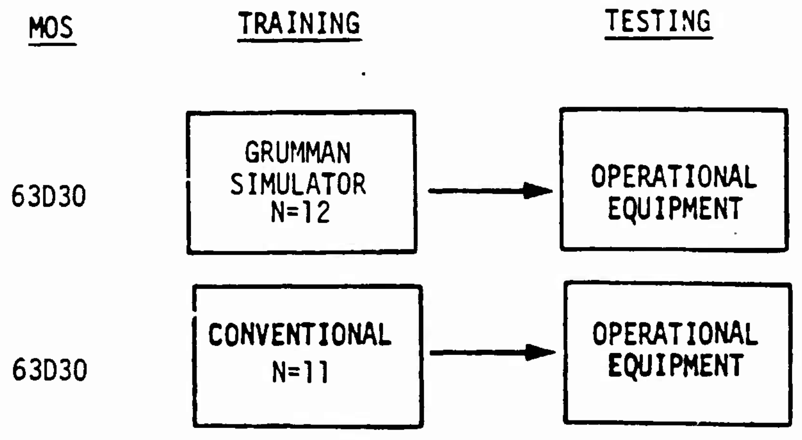


Figure 20. Design of Experiment 4.

Qualitative data recorded during Experiment 4 are presented and discussed in Volume III of this report.

Apparatus. The following equipment was utilized by students in Experiment 4:

- Grumman simulator
- M110A2 self-propelled 8-inch heavy howitzer
- Technical manuals for the M110A2 howitzer
- STE/ICE (Simplified Test Equipment/ Internal Combustion Engines)

- General mechanic's automotive tool kit

- Army Form DA 2404 (equipment inspection and maintenance worksheet)

- A voltage regulator for the M110A2 which was known to function properly.

Procedure. The procedure employed in Experiment 4 was similar to that described in previous experiments. Students were trained in groups of two and were tested individually by the SAI data collector. Training time averaged approximately 2.5 hours for the simulator-trained group and approximately 2 hours for the conventionally trained group. Time required to complete testing averaged 2 hours for both groups of students. The 63D30 simulator-trained students received instruction in the same lessons as were used by the 63H30 students in Experiment 3:

- Segment 0: Introduction, part 1

- Segment 1: Introduction, part 2

- Segment 2: VTM set-up and check-out tutorial (The VTM is a component of STE/ICE.)

- Segment 3: VTM set-up and check-out exercise

- Segment 8: Charging system problem 2 (defective voltage regulator)

Conventionally trained students were instructed on an Army Ordnance School curriculum which addressed the same task areas. As in the first three experiments, new performance tests and supporting data collection forms were developed and validated with help from Army School SMEs. These forms allowed the data collector to record the same measures as used in Experiments 1, 2, and 3. The original Ordnance School performance tests and the revised versions of these tests for the 63D30 students are presented in Appendix C.

Sixteen 63D30 students received training on instructional curriculum associated with the Grumman simulator; of these, 10 were available to serve as subjects in the experiment. The 11 63D30 students who received conventional training all were subsequently tested as participants in the experiment. One instructor conducted all training sessions for the two groups of students. Students were tested on their ability to perform the same eight subtasks as were described in Experiment 3. Testing procedures were identical to those described in Experiment 3.

Results

Analysis of student background via Mann-Whitney U-tests revealed no significant differences between the two groups of students in terms of age, grade, or ASVAB scores. Table 9 shows student background data for subjects who participated in Experiment 4.

E/C and C/E ratios were computed for percentages of performance test steps passed, time to complete each subtask, and number of data collector interventions required during testing. Subsequently, a series of 39 two-tailed Mann-Whitney U-tests were conducted to investigate differences in performance between the simulator-trained and conventionally trained students. Data were analyzed for the same dependent variables as were used in the first three experiments; tasks were reclustered into the same categories as those reported in Experiments 1 and 3.

Table 9

Characteristics of Trainees Involved in Experiment 4

Characteristic	Simulator Training	Conventional Training
Age:		
Mean	29.08	26.09
Standard Deviation	5.78	2.77
Grade: Range	E5-E7	E5-E6
ASVAB Scores:		
General Maintenance		
Mean	100.86	111.5
Standard Deviation	9.23	26.08
Mechanical Maintenance		
Mean	107.86	119.5
Standard Deviation	11.34	15.86
General Technical		
Mean	92.86	106.67
Standard Deviation	5.52	18.52
Electronics		
Mean	105.29	119.83
Standard Deviation	9.66	12.45

E/C and C/E Ratios. Inspection of Table 10 reveals a mean E/C ratio on the percentage of performance test steps passed of over 90 for the 63D30 experiment. Note that the E/C ratio was higher than 80 for seven of the eight tested subtasks. The mean C/E ratio for time to complete all eight subtasks was slightly greater than 73. Two subtasks provide C/E ratios exceeding 90, while the remaining six subtasks provide C/E ratios below 70.

Table 10

E/C and C/E Ratios for 63D30 Students

Task	E/C Ratio Percent Steps Passed	C/E Ratio Time to Complete Task	C/E Ratio Data Collector Interventions
Confirm malfunction	91.49	90.91	14.29
Troubleshoot electrical system	77	61.90	-[a]
VTM hook-up and check-out	92.63	68.69	39.13
Charging circuit test	100	60	111.11
Troubleshoot charging circuit	98.98	69	81.25
Remove/replace voltage regulator	82.29	62.26	46.15
VTM hook-up and check-out	89.69	112	62.5
Charging circuit test	96.91	65.52	66.67
	$\bar{x}$ = 91.12	$\bar{x}$ = 73.79	$\bar{x}$ = 60.16

[a]Not applicable (conventional group required no data collector interventions)

There was a wide range of C/E ratios for instructor interventions. These ratios ranged from 111.11 to 14.29. Performance of experimentally trained students exceeded that of conventionally trained students for one subtask (i.e., charging circuit test). The mean C/E ratio was slightly greater than 60.

Percent Steps Passed. An overall U-test for the combined eight subtasks indicated that conventionally trained students passed more steps than did students trained on the Grumman simulator, $U = 27.5$, $p<.05$. Subsequent U-tests indicated that conventionally trained students passed significantly more steps in the performance tests than did simulator-trained students for three of the eight subtasks tested: troubleshoot electrical system task, $U = 33$, $p<.05$; the remove/replace voltage regulator task, $U = 15$, $p<.01$; and the VTM hook-up and check-out task, $U = 30$, $p<.05$. Figure 21 presents these data.

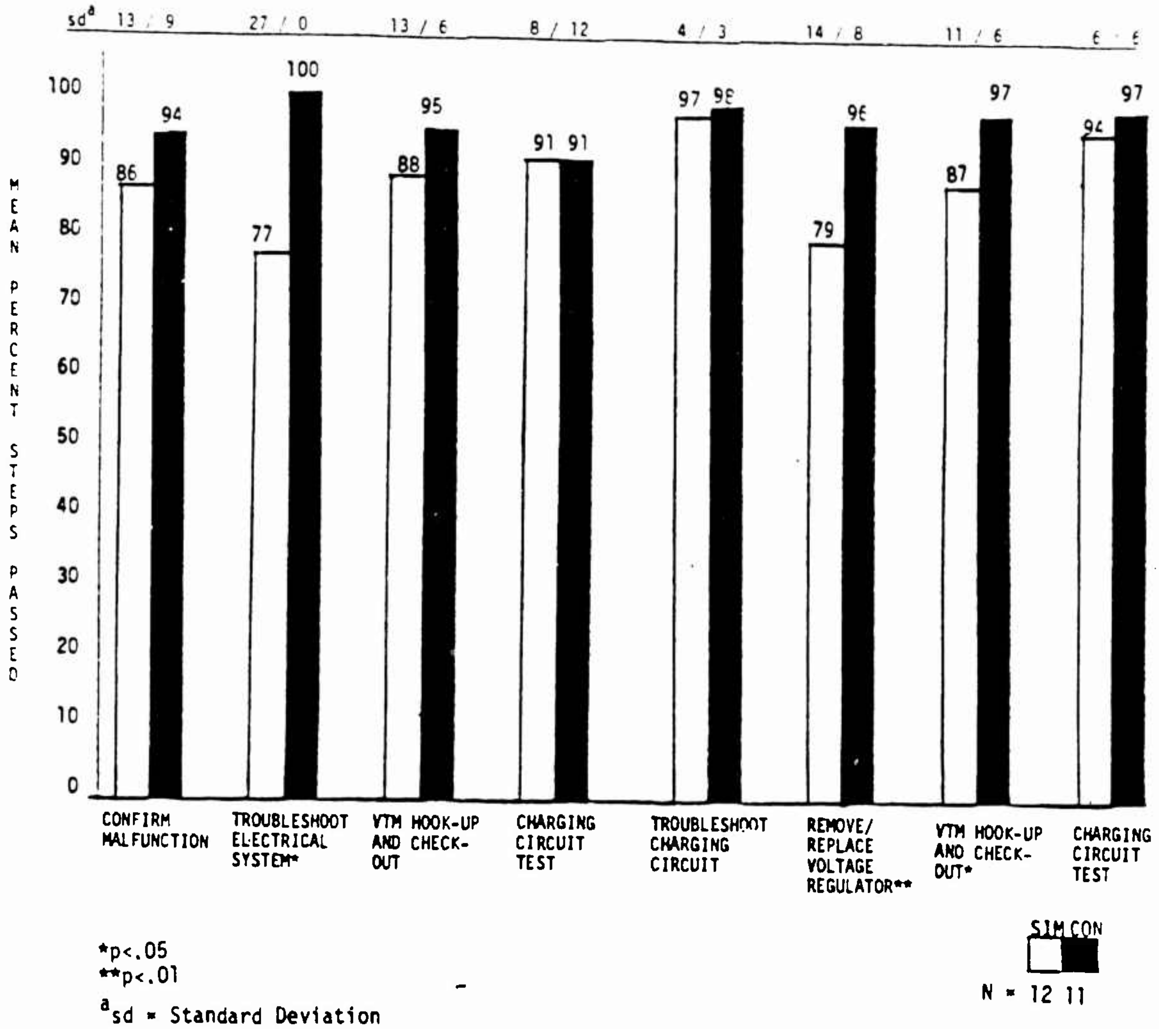


Figure 21. Mean percent steps passed by 63D30 students.

Time to Complete Task. An overall U-test for the combined eight subtasks indicated significantly faster performance for conventionally trained subjects than for simulator-trained subjects, $U = 27$, $p<.05$. This overall difference was apparently due to the existence of significant differences between the two training conditions for two of the eight subtasks performed by the 63D30 students. Conventionally trained students took less time than simulator-trained students to perform the first charging circuit test, $U = 28.5$, $p<.05$, and the second charging circuit test, $U = 31$, $p<.05$. (See Figure 22.)

Data Collector Interventions. An overall U-test for all eight subtasks combined indicated no significant difference between the two groups on the number of data collector interventions required during testing. Subsequent U-tests for each subtask indicated that conventionally trained students required significantly fewer data collector interventions than did simulator-trained students for the remove/replace voltage regulator subtask, $U = 32.5$, $p<.05$; however, all other two-way comparisons by subtask were not significant. Figure 23 shows these data.[6]

Reclustered Tasks - Percent Steps Passed. Conventionally trained students performed significantly more performance test steps correctly than did simulator-trained students for two of the six reclustered tasks (i.e., the reclustered TM selection task, $U = 31$, $p<.05$, and the reclustered control actuation task, $U = 24.5$, $p<.05$). These data are shown in Figure 24. Refer to footnote 6.

Reclustered Tasks - Data Collector Interventions. Conventionally trained 63D30 students required significantly fewer instructor interventions than simulator-trained students for only one of the six reclustered tasks - the control actuation task, $U = 30$, $p<.05$ as shown in Figure 25. Refer to footnote 6.

Discussion

Although the mean E/C ratio for percentage of performance test steps passed was high, C/E ratios for time to complete task and data collector interventions were not as high as the C/E ratios reported in the previous experiments.

Significant differences which emerged between the two groups of 63D30 students indicated superior performance by the conventionally trained students in every case. These differences varied by subtask and dependent variables.

Two differences between the training conditions which occurred with regularity involved the remove/replace voltage regulator subtask and the reclustered control actuation task. Superior performance by the conventionally trained group on the voltage regulator remove/replace subtask may have

[6] Note: Although many of the subtask comparisons shown in Figure 23 may appear significant based upon the height of the bars, as was the case in Experiment 3, many tied scores occurred on this measure; thus, the U statistic as applied is conservative. Refer to footnote 5 on page 41.

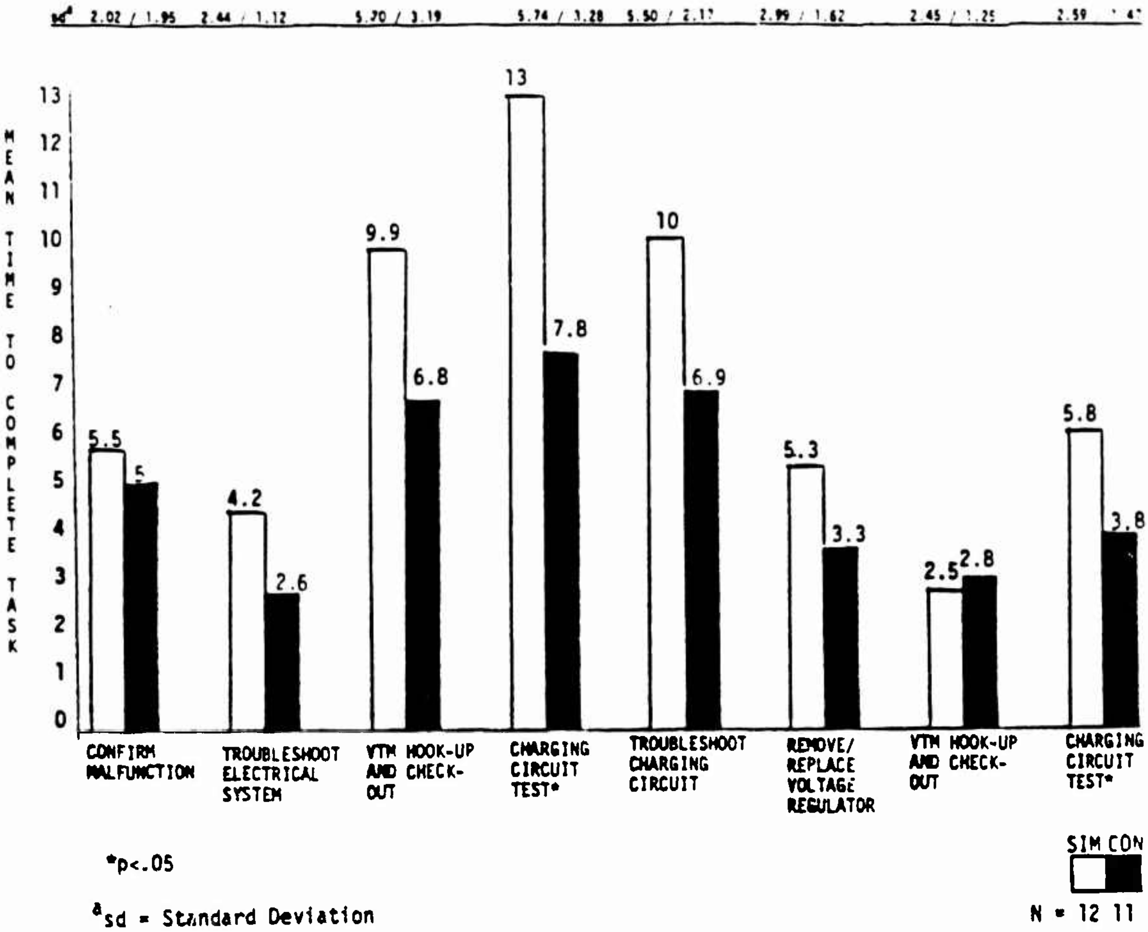


Figure 22. Mean time to complete task for 63D30 students (minutes).

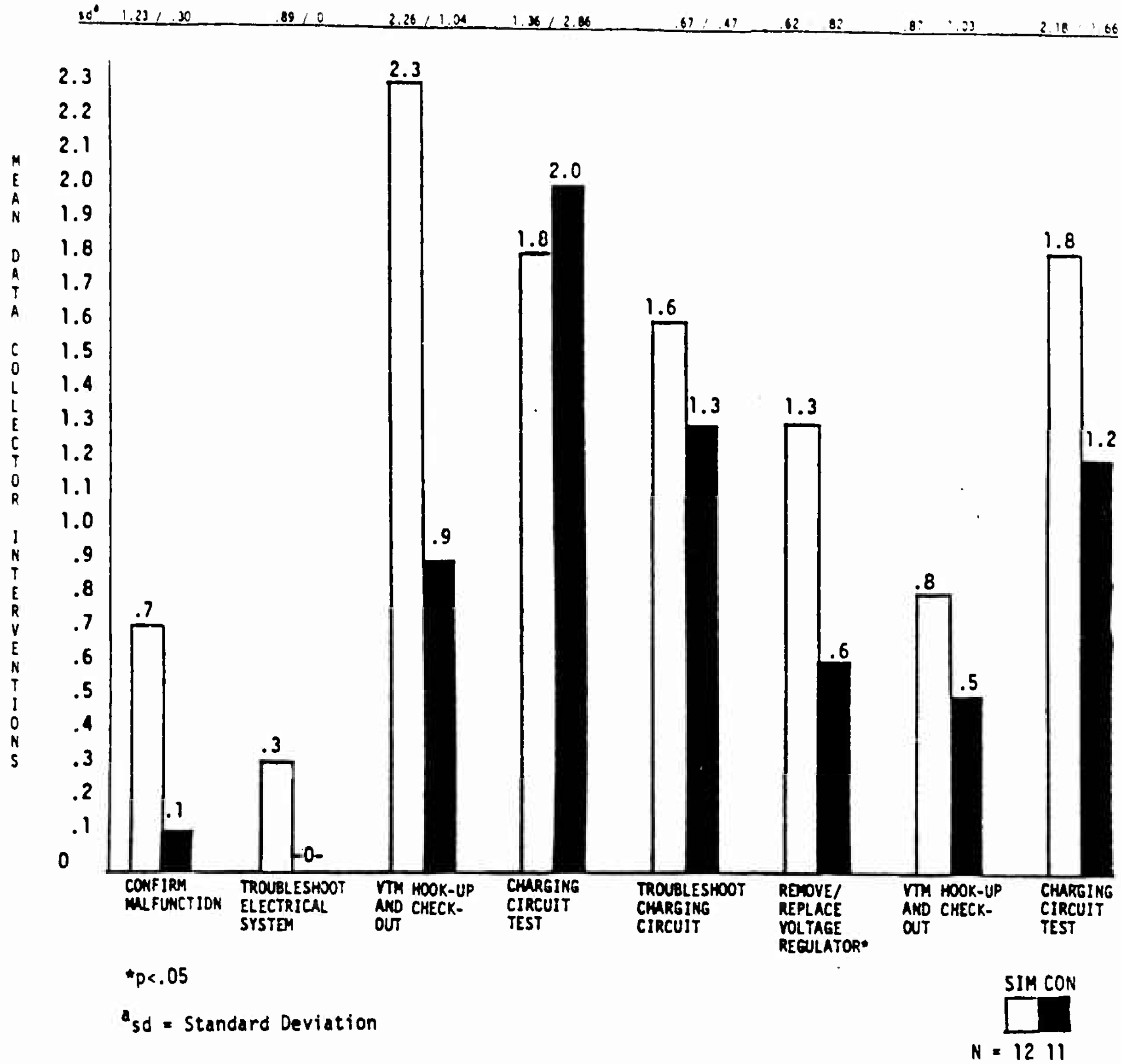


Figure 23. Mean data collector interventions for 63D30 students.

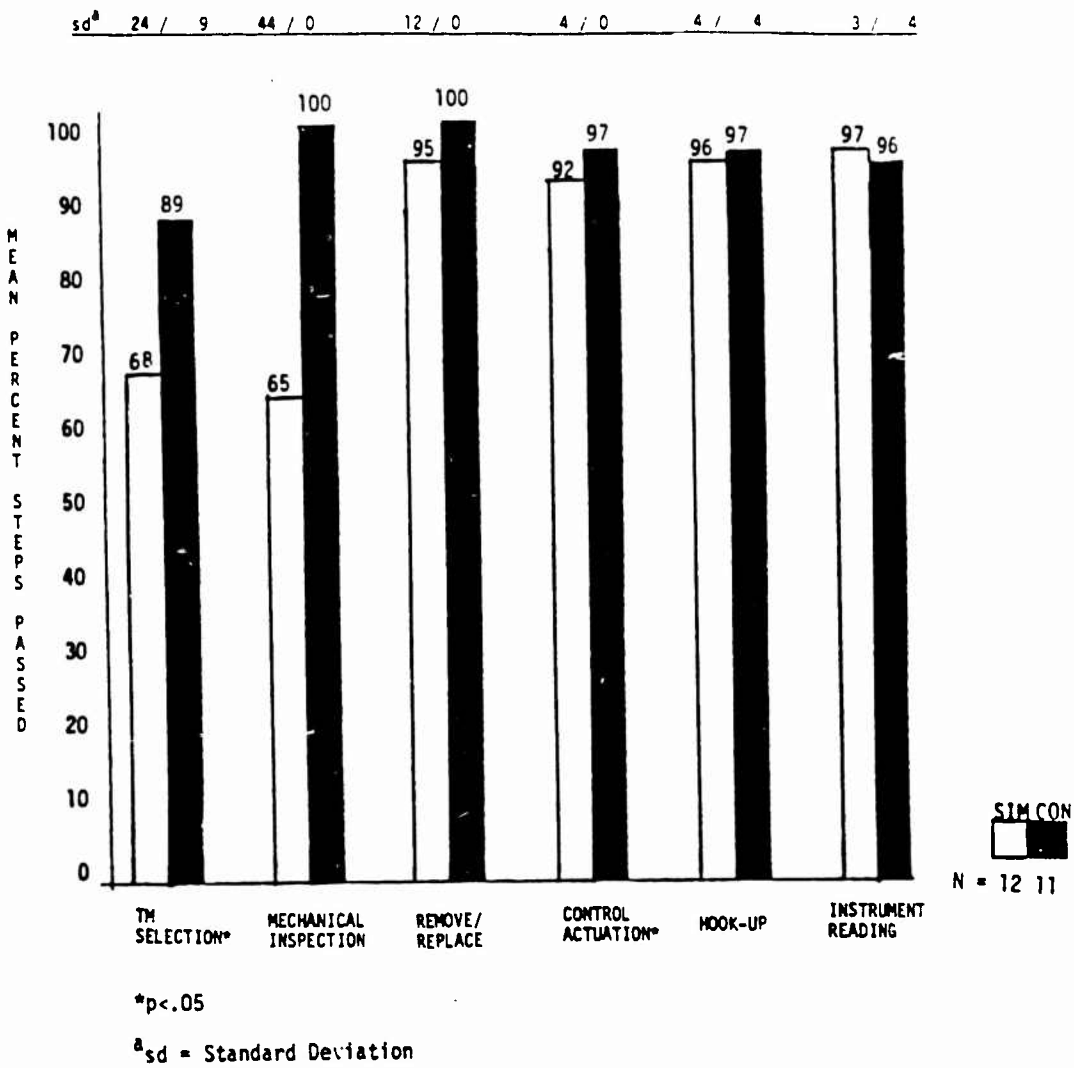
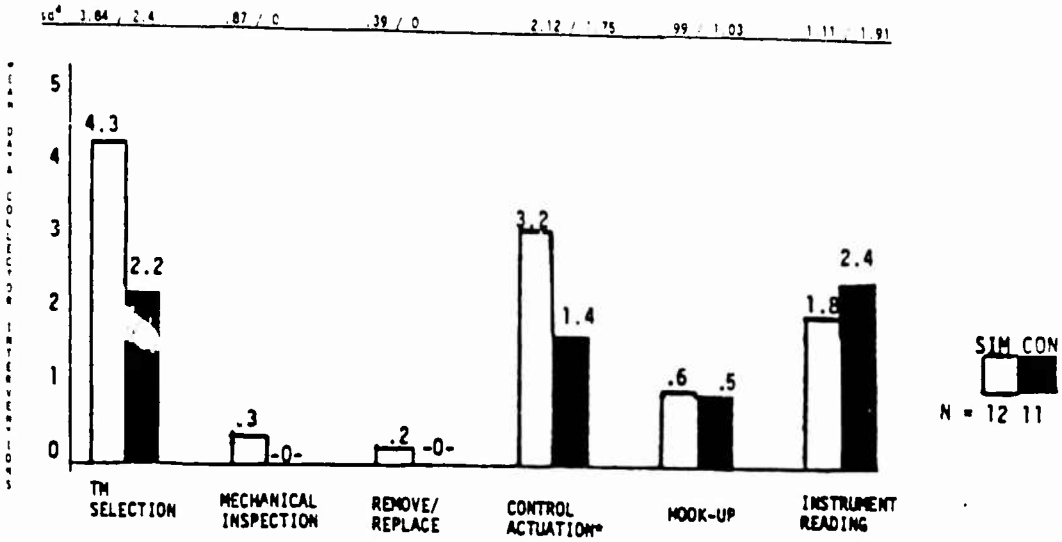


Figure 24. Mean percent steps passed by 63D30 students for reclustered tasks.



*p<.05

[a]sd = Standard Deviation

Figure 25. Mean data collector interventions for 63D30 students for reclustered tasks.

been due to a training emphasis which included a description of the location of the voltage regulator on the vehicle, and precise instructions for its removal and replacement. The 3-D module of the Grumman simulator, however, does not indicate the location of the voltage regulator on the vehicle, and remove/replace activities as trained by the simulator-based curriculum consist simply of indicating that the component requires replacement. It appears that the Grumman device, as configured, is more effective for training students to identify faulty components than it is for training students to remove/replace components. It would appear that the device, as configured, should be used to supplement training. If the device were to be used to replace conventional training, fidelity of the 3-D module should be dramatically increased.

Superior performance by the conventionally trained students varied by subtask and dependent variable. For example, conventionally trained students exhibited significantly superior performance on the percent steps passed measure for subtasks 2, 6, and 7 while on the time to complete task measure, their performance was superior to that of the simulator-trained students on subtasks 4 and 8.

Superior performance by the conventionally trained students on the remove/replace voltage regulator subtask (on the percent steps passed and data collector interventions measures) conflicts with the finding in Experiment 3 which indicated superior performance by the simulator-trained 63H30 students for this subtask. This discrepancy may have resulted from differences in the skill levels of the students participating in these two experiments. In both experiments, the difference in performance between the two groups resulted from differential performance on a series of activities (performance test steps 1, 2, and 3) that follow identification of the faulty component and precede the removal/replacement of this component. The 63H30 students (Experiment 3) had little experience with the M110A2 vehicle or with the STE/ICE kit. For these students, simulator training aided the performance of the three steps in question. The 63D30 students (Experiment 4), however, did have considerable experience with both the M110A2 vehicle and the STE/ICE kit. For these students, simulator training appeared to interfere with their ability to perform these steps.

This result illustrates the importance of using a training device for appropriate tasks and skill levels. While the Grumman device excelled in training a certain subtask for inexperienced students, it appeared to inhibit performance on this same subtask for more highly experienced students. Further research is necessary to identify the types of tasks and student skill levels for which training on the AMTESS devices are most appropriate.

Experiment 5

Experiment 5 addressed transfer-of-training issues for students trained on the curriculum associated with the Seville/Burtek device at Fort Bliss, Texas. In Experiment 5, students from MOS 24C10 (Hawk Missile Firing Section Mechanic) were trained on several Hawk system maintenance tasks, using simusimulator-based or conventional training methods. The students were then tested on their ability to perform a subset of these tasks on operational Hawk radar equipment.

Constraints imposed by the U.S. Army Air Defense School seriously degraded the extent to which a controlled experimental design could be implemented at Fort Bliss. Due to School requirements, the number and types of problems upon which data could be collected could not be placed under experimental control. Further, students in the conventionally trained group were trained in a so-called "lockstep" fashion (where the primary mode of instruction is lecture based, and where entire classes move through the curriculum *en masse*, as opposed to individual student pacing); whereas simulator-trained students were trained in a self-paced format. The results reported in Experiment 5 are limited by this major confound as well as by a variety of additional constraints encountered at Fort Bliss.

Method

Subjects. Twenty-two students from the 24C10 MOS participated in Experiment 5. All 24C10 students had previously completed a general electronics course as well as two courses related specifically to the operation of the Hawk radar system. All were familiar with the use of TMs, with radar fundamentals, and with the Fault Isolation Procedure (FIP) troubleshooting strategy which employed the proceduralized approach to maintenance troubleshooting used at the Air Defense School.

Design. The overall design for Experiment 5 is presented in Figure 26. Twelve students received conventional training (i.e., using a lecture-based method and operational Hawk radar equipment for hands-on practice) and 10 students were trained on the curriculum associated with the Seville/Burtek device. Detailed performance tests were developed in a manner highly similar to that used at APG. Data collection forms allowed for the following types of information to be recorded:

- o Student identification and background
- o GO/NO GO scores for each step on the performance test
- o Time to complete each task and subtask
- o Comments about the subject or testing environment

(Note: Data on the number of required instructor interventions during performance testing were not available for either Experiment 5 or for Experiment 6 since performance tests at Fort Bliss were administered by School personnel who did not collect data on this measure.)

Since the data base for use in comparing students trained via the two training conditions was extremely limited, an effort was made to collect additional data from both groups. These data included:

- o Instructor ratings - Following completion of the performance test, instructors rated student's performance on a series of 7-point scales dealing

with student's use of tools, knowledge of terminology, degree of hesitation while performing the task, etc.

- Written tests - Multiple choice written tests were administered by the School to both groups of students at two different times: halfway through the course, and upon completion of the course.

- Practical tests - The test sheets used by instructors during students' practical exams were obtained and analyzed.

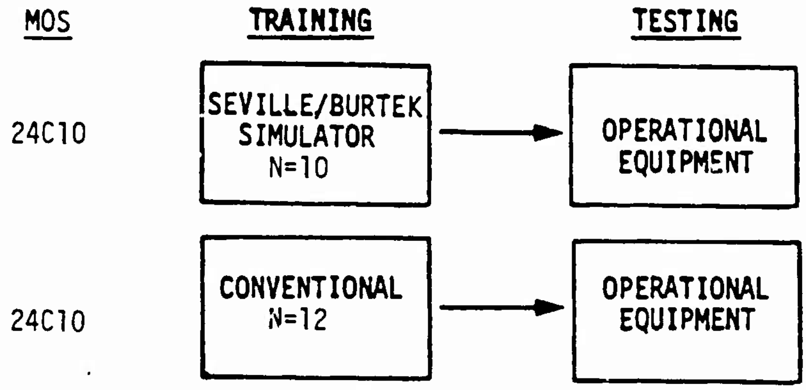


Figure 26. Design of Experiment 5.

Performance tests, as well as instructor rating forms, written test forms, and practical test forms, are presented in Appendix D. In addition to these sources of information, the additional sources of data described in previous experiments were also collected in Experiment 5. This information included:

- Initial instructor questionnaires

- In-depth instructor and course developer questionnaires

- Student questionnaires

- Data collector's notes

- Structured interviews with knowledgeable Army School personnel

These data are reported and discussed separately in Volume III of this report.

Apparatus. The following equipment was used during Experiment 5:

- Seville/Burtek simulator
- Improved Hawk High Power Illuminator Radar transmitter
- Technical manuals for the transmitter
- Test equipment: wavemeter test set, multimeter, jumper cables
- Screwdriver

Procedure. Experiment 5 differed from the previously reported studies in that considerably less experimental control was exercised. Instructors who trained students on the simulator-based curriculum were informed of the requirement for standardized procedures and complied with this request to the best of their ability; however, instructors who trained students conventionally did not attempt to maintain such rigorous standardization.

Conventionally trained students received their training in lockstep fashion over a period of eight days. That is, a group of eight to 12 students attended lectures, then broke into smaller groups to practice "hands-on" tasks directly on the Hawk radar transmitter. Students worked on the radar in groups of two. One student acted as a "reader" for the other student who practiced troubleshooting activities on the transmitter. This team of two students acted as a demonstration team for troubleshooting training. The remaining students in the group observed this activity from their desks and used schematics in TMs to follow the troubleshooting problem. School administrators would not allow for alteration of this training procedure.

Training for students in the simulator-based training group was also completed in eight days. Students performed an average of 10 of the 17 troubleshooting exercises which could be taught on the simulator (i.e., seven high voltage exercises and 10 exercises involving a number of other circuits). Students read the self-paced written materials and then performed the required exercises on the simulator. Most students performed the exercises in pairs with one student acting as the "reader" for the other student. After completing the hands-on exercises, the students returned to their desks to complete written exercises as required by the curriculum.

Following completion of simulator-based training, Army School personnel allowed students to practice on the operational Hawk radar equipment prior to participating in performance testing activities. School personnel indicated that performance testing prior to equipment familiarization was inappropriate. Thus, each student practiced at least two troubleshooting problems before taking the performance test. This externally imposed confound undoubtedly affected the results of Experiment 5.

Since the degree of experimental control differed substantially across the two groups of students, strict control over the tasks included in the

evaluation was not possible. All students trained on the simulator were tested on the following problems:

- Weekly check procedures
- Troubleshoot problem #19 - short J2, degen IF amplifier
- Troubleshoot problem #20 - W2P1 open on AF-RF amplifier
- Troubleshoot high voltage (HV) - bad PA

In addition, data were collected on as many of the following practice problems as time permitted:

- Troubleshoot problem #19 - bad reference balance mixer crystals
- Troubleshoot problem #18 - bad arc detector crystal
- Troubleshoot problem #17 - open filament V9 KTCA
- Troubleshoot problem #10 - bad V6, cavity AFC lock control

Very little control of training procedures was possible in the case of conventionally trained students. These students were permitted by the Air Defense School to perform only one troubleshooting problem. Further, this problem varied across students. A comparison of the tasks used to assess student performance for the two groups is presented in Tables 11 and 12. Lack of control of these training procedures seriously reduced the number of tasks on which the performance of conventionally trained and simulator-trained students could be directly compared.

All testing was conducted individually by school personnel. Data obtained for analyses in Experiment 5 were obtained by the SAI data collector who unobtrusively observed student performance during the course of the School testing. Students were accustomed to having their performance monitored by a data collector during training; therefore, the presence of a data collector during testing was not a novel or degrading factor.

Testing was monitored, but not conducted, by the data collector, since the highly complex and dangerous nature of a radar transmitter required that the testing process be conducted directly by a SME. (In Experiments 1 through 4, the data collector actually administered the performance tests since the tasks involved in those experiments were relatively simple and safe.)

Conventionally trained students received instruction from one instructor and were tested by a second instructor. Students were required to troubleshoot one malfunction successfully within 45 minutes. Verbal and nonverbal communication between student and instructor was frequent during testing.

Table 11

Summary of Transfer-of-Training Data Collected during the Evaluation of the Seville/Burtek simulator at Fort Bliss

	CONDITION/S#	WEEKLY CHECKS PERFORMED	TROUBLESHOOTING PROBLEMS PERFORMED						
	CONVENTIONAL								
Students	1	NO	19						
	2	NO	19						
	3	NO	19						
	4	NO	19						
	5	NO	19						
	6	NO	19						
	7	NO	19						
	8	NO	19						
	9	NO	20						
	10	NO	20						
	11	NO	20						
	12	NO	20						
	SIMULATOR								
Students	1	YES	19	18	17	10	9	20	HV
	2	YES	19	18	17	10	9	20	HV
	3	YES	19	18	17	10	9	20	HV
	4	YES	19			10	9	20	HV
	5	YES	19			10	9	20	HV
	6	YES	19	18	17	10	9	20	HV
	7	YES		18	17		9	20	HV
	8	YES		18		10	9	20	HV
	9	YES		18			9	20	HV
	10	YES	19	18			9	20	HV

HV = High Voltage Problem

Table 12

Number of Students Tested for Tasks Which Were Trained with the Simulator and Which Were Trained Conventionally

Condition	Problem #19	Problem #20
Conventional	N = 8	N = 4
Simulator	N = 7	N = 10

During testing, all conventionally trained students used the Fault Isolation Procedure (FIP) troubleshooting approach. This approach required students to follow a detailed set of procedures in order to identify faulty components. All instructors required that students start at step 1, but various instructors allowed students to skip steps as they felt appropriate. This was presumably done to svae time for the student. Appendix D shows the FIP-based performance test. No simulator-trained students utilized FIP. Rather, they used a "last good/first bad" method of troubleshooting. This method, instead of following a prescribed set of steps, required that students use schematics to trace paths through the relevant circuitry for good and bad indications. Appendix D shows the performance test used to assess simulator-based students trained in the "last good/first bad" troubleshooting technique. Troubleshooting data for both groups are reported as a ratio of steps passed to steps attempted.

Testing was usually conducted on the ninth day of training. For one group of four conventionally trained students, however, a period of two weeks elapsed before the students were available for testing. Two written multiple choice tests (developed at Fort Bliss by the missile school) were administered to all conventionally trained students and to eight of the ten simulator-trained students. One test was administered midway through the training program while a second was administered at the end of the course. (The remaining two simulator-trained students were available to take only the end-of-course test.) Simulator-trained students were tested in the same general manner as were the conventionally trained students. Several differences in testing procedures did, however, occur between the groups:

- The same instructor trained and tested simulator-trained students; different instructors performed these functions for conventionally trained students.

- Simulator-trained students' practical exam scores (school) reflect their performance on three troubleshooting tasks; conventionally trained students were rated on their performance for one task.

- All simulator-trained students were tested on the same set of tasks:

  - Weekly check procedures,
  - Problem #9,
  - Problem #20, and
  - High voltage problem (bad PA tube).

- Conventionally trained students were tested on either problem #19 or problem #20.

Any comparison between the two groups for problem #19 must take into account the fact that this was a "practice" problem for the simulator-trained students, and a "test" problem for the conventionally trained students. Further, conventionally trained students received previous training on the skills associated with problem #19, while simulator-trained students did not.

Results

An analysis of student background data was conducted to determine if differences existed between the two groups of students prior to the start of training. As was true of similar analyses conducted in the experiments at APG, Mann-Whitney U-tests revealed no statistically significant differences between the simulator-trained and conventionally trained groups in terms of age, grade, and ASVAB scores (general maintenance, mechanical maintenance, general technical, electronic). Trainee characteristics are presented in Table 13.

E/C and C/E ratios were computed for percentage of performance tests steps passed, time to complete each task, instructor ratings, and Army Air Defense School written test scores. Subsequently, a series of 16 two-tailed Mann-Whitney U-tests were conducted to investigate differences in performance between the conventionally trained and the simulator-trained students.

E/C and C/E Ratios. The E/C scores presented in Table 14 reveal that simulator-trained students performed almost 90 percent as well as conventionally trained students for percentage of performance test steps passed. In one case, the E/C ratio measure exceeded 100, indicating superior performance for simulator-trained students. The mean E/C ratio for instructor ratings exceeded 85, while the mean E/C ratio for School written exams was slightly less than 99. The mean C/E ratio for time to complete task exceeded 75.

Percent Steps Passed. Students trained on the Seville/Burtek simulator-based curriculum passed slightly more test steps on the determine bad

Table 13

Characteristics of Trainees Involved in Experiment 5

Characteristic	Simulator Training	Conventional Training
Age:		
Mean	23	20.92
Standard Deviation	3.2	2.54
Grade: Range	E2-E3	E2
Time in Service:		
Mean	8.7 months	10.67 months
Standard Deviation	.68	4.38
ASVAB Scores:		
General Maintenance		
Mean	113.5	115.6
Standard Deviation	10.38	10.86
Mechanical Maintenance		
Mean	108.1	113.46
Standard Deviation	10.29	10.27
General Technical		
Mean	115.6	117.92
Standard Deviation	8.04	11.04
Electronics		
Mean	113.8	117.6
Standard Deviation	8.4	7.2

Table 14

E/C and C/E Ratios for 24C10 Students

Task	E/C Ratio for Percent Steps Passed	C/E Ratio for Time to Complete Task
19 Determine bad indication	113.64	125
19 Troubleshooting	82.56	47.56
20 Determine bad indication	95	84.62
20 Troubleshooting	66.67	43.03
	$\bar{x}$ = 89.47	$\bar{x}$ = 75.05

	E/C Ratio for Instructor Ratings	
Skill Areas:		
Tool selection	92.42	
Tool use	100	
Equipment nomenclature	87.27	
Student hesitation	86.54	
Task terminology	63.08	
	$\bar{x}$ = 85.86	

	E/C Ratio for School Exams	
Exam:		
1st written test	97.65	
2nd written test	101.19	
Practical exam	97.80	
	$\bar{x}$ = 98.88	

indication portion of problem #19 than did conventionally trained students, $U = 14$, $p<.06$.[7] Students trained conventionally passed a significantly greater number of performance test steps than did students trained on the Seville/Burtek simulator for the troubleshooting portion of problem #19, $U = 13$, $p<.05$. Data for percent steps passed are presented in Figure 27.

Time to Complete Task. Students trained conventionally took significantly less time than did students trained on the simulator to complete the troubleshooting portion of both problem #19, $U = 6$, $p<.01$, and problem #20, $U = 3.5$, $p<.05$. These data appear in Figure 28.

Instructor Ratings. Data for instructor ratings appear in Figure 29. Conventionally trained students received instructor ratings which were significantly higher than those received by simulator-trained students for their knowledge of task terminology, $U = 15$, $p<.05$. All other instructor rating measures did not show significant differences among training groups.

School Exams. No significant differences in performance were detected between the simulator-trained group and the conventionally trained group for any of the exams administered by the school:

- First written test
- Second written test
- Practical exam

Data for school exams are presented in Figure 30.

Data Collector Intervention and Reclustered Task Analyses. The varying and ubiquitous nature of student-instructor interventions at Fort Bliss precluded any analysis of this variable. Further, tasks were not amenable to reclustering into more homogeneous skill and knowledge areas due to the nature of the troubleshooting tasks performed.

Discussion

The mean E/C ratios for percentage of performance test steps passed, instructor ratings, and Army School exams were high, indicating that simulator-trained students performed nearly as well as conventionally trained students in terms of this measure. However, the mean C/E ratio for time to complete task was somewhat lower than the mean E/C ratio for percent steps passed. Numerous confounding factors serve to cloud the interpretation of results from Experiment 5. First, conventionally trained students received so-called "lockstep" training while the curriculum associated with

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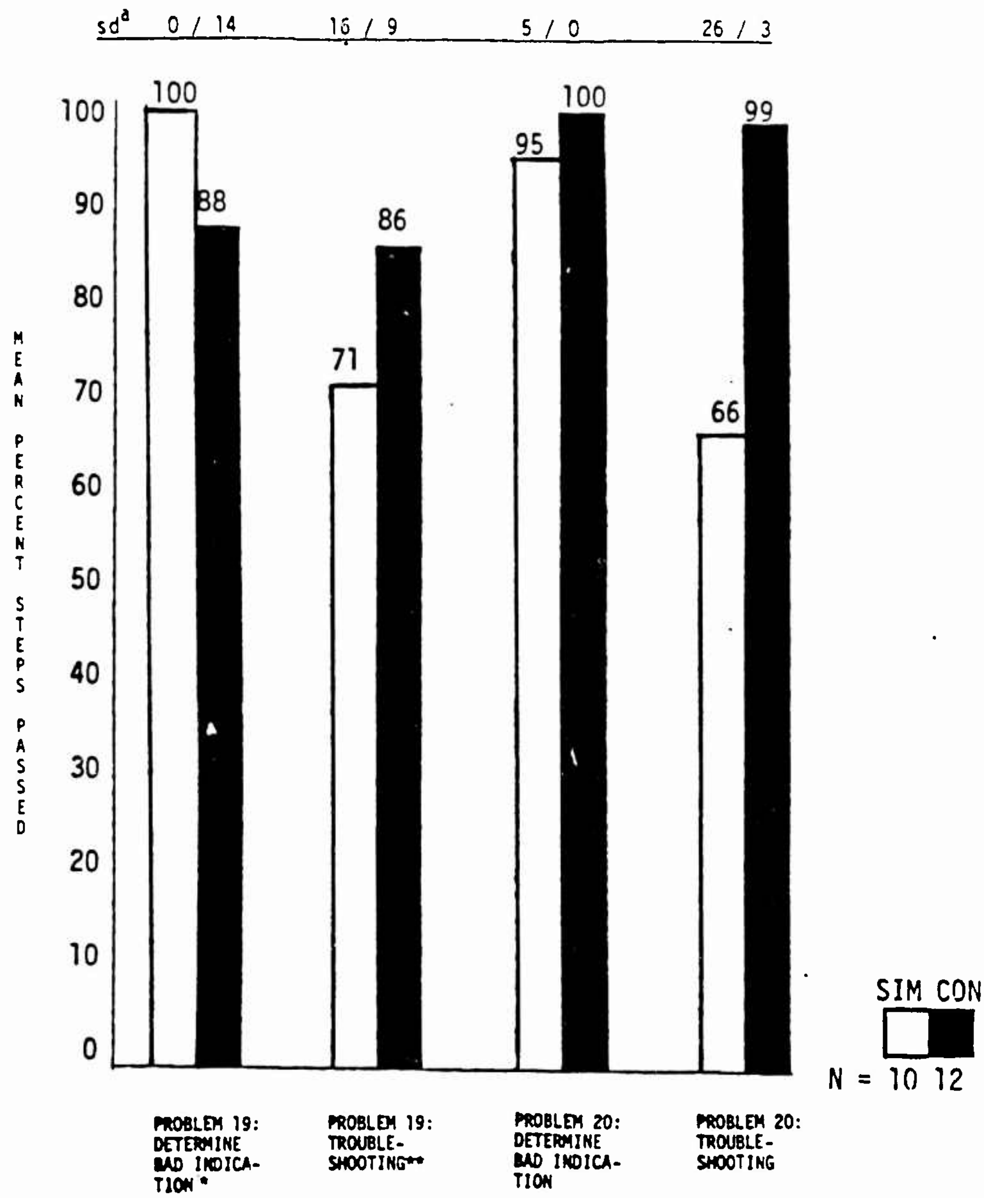
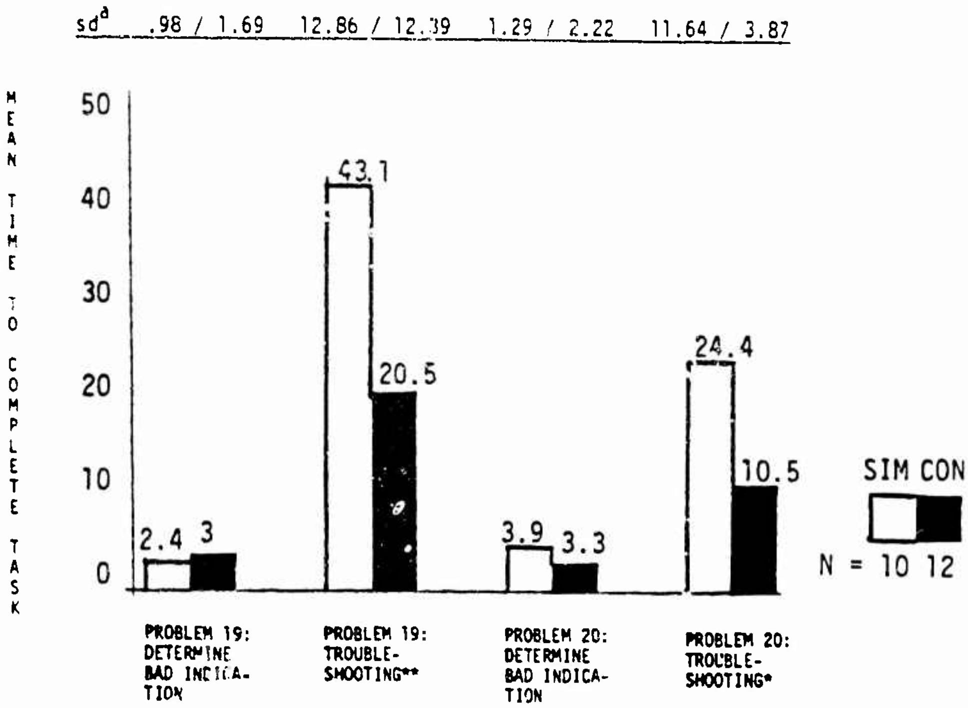
[7] The value of the U statistic is conservative in this case due to a large number of identical scores on this problem. That is, since almost all students passed all steps on the performance test, the value of the U statistic is conservative. Refer to footnote 5 on page 41.



*p = .06
**p<.05
[a]sd = Standard Deviation

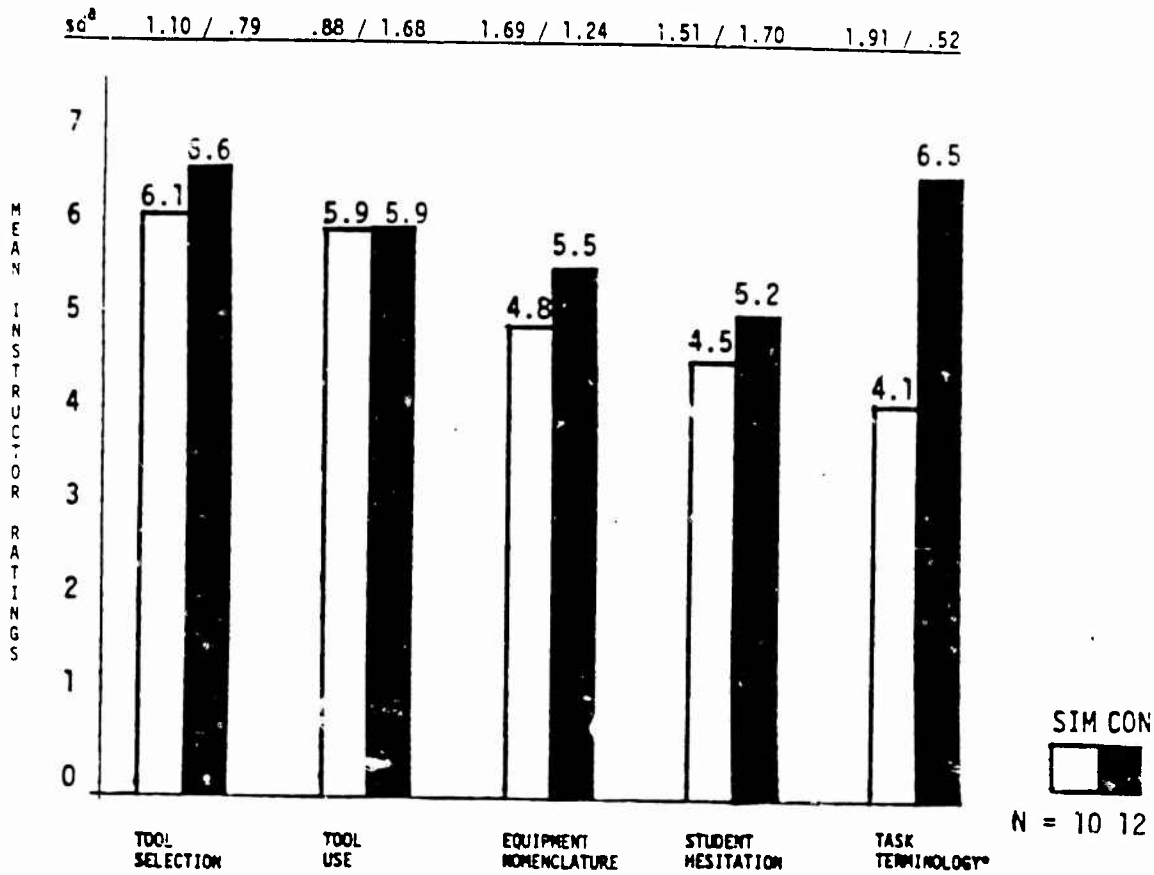
Figure 27. Mean percent steps passed by 24C10 students.



*$p<.05$
**$p<.01$

[a] sd = Standard Deviation

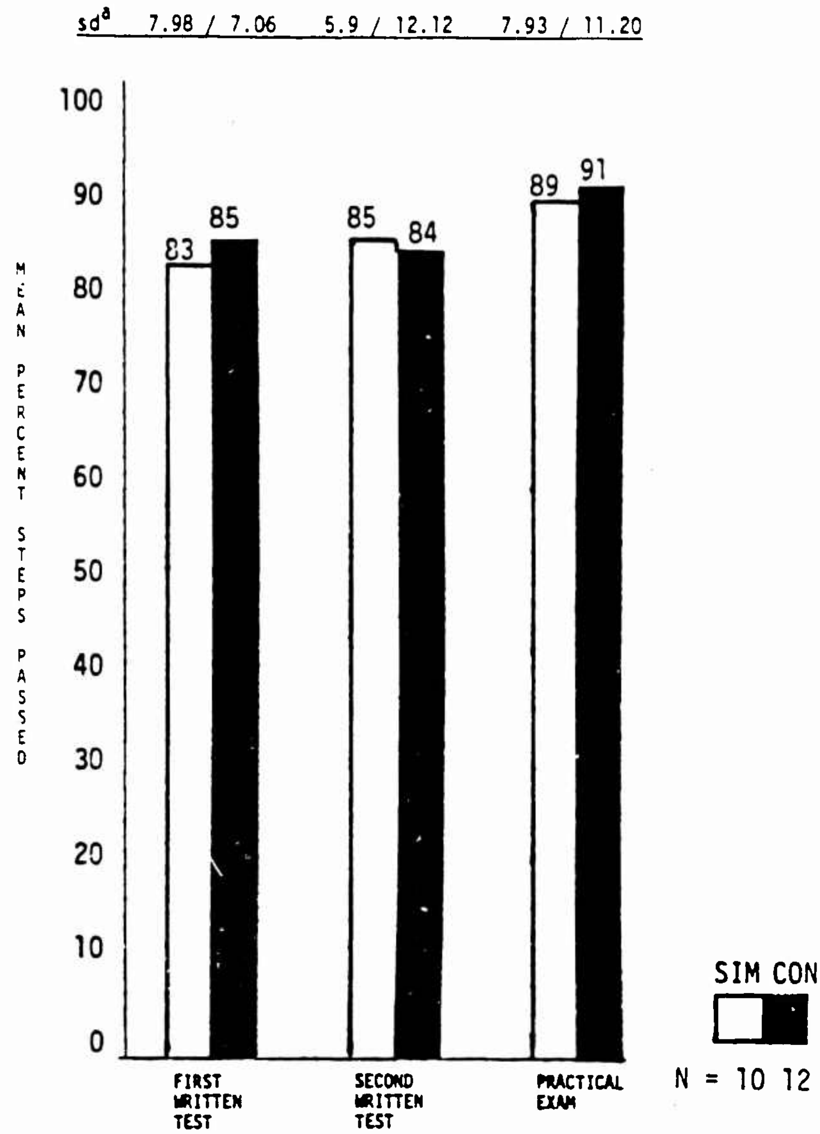
Figure 28. Mean time to complete task for 24C10 students (minutes).



*p<.05

[a]sd = Standard Deviation

Figure 29. Mean instructor ratings for 24C10 students.



[a]sd = Standard Deviation

Figure 30. Mean percent steps passed by 24C10 students for school administered exams.

simulator-based training was self-paced. Second, conventionally trained students were taught (and subsequently used) the FIP troubleshooting method, while the simulator-trained students were taught (and subsequently used) the "last good/first bad" troubleshooting method. Third, conventionally trained students had received some degree of practice on problem #19 before being tested on it, while simulator-trained students performed problem #19 as a training exercise. Fourth, very few data points (four) exist for conventionally trained students on problem #20. Fifth, the conventionally trained group was trained and tested by two different instructors, while one instructor conducted all training and testing for the simulator-trained group.

Bearing these facts in mind, where differences between the groups did appear, the conventionally trained group's performance was generally superior to that of the simulator-trained group. This difference is most noticeable in the time required to complete troubleshooting problems #19 and #20. It seems likely, however, that conventionally trained students' use of the FIP troubleshooting technique was the primary factor which contributed to more successful troubleshooting outcomes in a shorter period of time than was the case with simulator-trained students. Although the FIP method does not require students to fully comprehend the logic of the FIP troubleshooting procedure, the method helps students to identify faulty components in a short period of time.

For the problems that were comparable between groups, the following E/C ratios occurred for the percentage of performance steps passed:

- o Problem #19 - Determine indication: 114
- o Problem #19 - Troubleshoot: 83
- o Problem #20 - Determine indication: 95
- o Problem #20 - Troubleshoot: 67

The E/C ratios for instructor ratings and School written exams were quite high as were the C/E ratios for time to complete task. Thus, even though the conventionally trained group performed better than the simulator-trained group, the simulator did train the tasks nearly as well as conventional training.

Experiment 6

In Experiment 6, a case study approach was used to evaluate training provided by the Grumman device at Fort Bliss, Texas. It was not possible to make direct comparisons between simulator-trained students and conventionally trained students in Experiment 6 because the Missile School at Fort Bliss was unable to provide students for a conventional training condition. Thus, the data reported in this experiment are primarily descriptive. The only reported direct statistical comparisons concern comparisons between performance of students trained on the Seville/Burtek simulator (Experiment 5) and performance of students trained on the Grumman simulator. These data were available for only two tasks (one of which was composed of 11 subtasks.)

The majority of the data collected during Experiment 6 were qualitative in nature and are reported separately in Volume III of this report.

Method

Subjects. Students trained on the curriculum associated with the Grumman simulator were job incumbents in one of three MOSs. Three students were Improved Hawk Fire Control Mechanics (24E), four were Improved Hawk Information and Coordination Control Mechanics (24G), and three were Improved Hawk Master Mechanics (24R). All students had previously received training in basic electronics and were familiar with basic troubleshooting procedures, the use of TMs, and the use of flowcharts.

Design. The design for this study is presented in Figure 31. Ten students were trained on the curriculum associated with the Grumman device. These students were subsequently tested on the simulator and on operational equipment. As in the other experiments, detailed performance tests were developed with input from School SMEs. Data collection forms allowed for the following types of information to be recorded:

- o Student identification and background
- o GO/NO-GO scores for each step on the performance test
- o Time to complete each task and subtask
- o Comments about the subject or testing environment

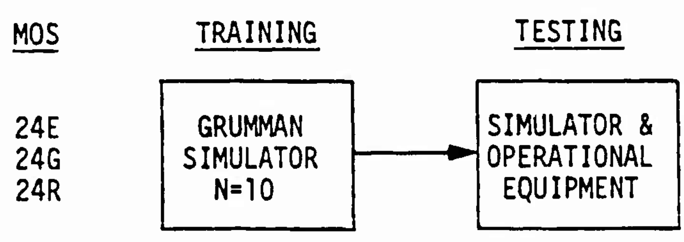


Figure 31. Design of Experiment 6.

Data collection forms developed for the evaluation of the Grumman device are presented in Appendix E.

Additional data were also recorded. These data (reported in Volume III of this report) included:

- o Initial instructor questionnaires
- o In-depth instructor and course developer questionnaires

o Student questionnaires

o Data collector's notes

o Structured interviews with knowledgeable Army School personnel

Apparatus. The following equipment was used during Experiment 6:

o Grumman simulator

o Improved Hawk High Power Illuminator Radar transmitter

o Technical manuals for the transmitter

o Screwdriver

Procedure. SME School-based instructors at Fort Bliss conducted all training and testing sessions in the presence of the SAI data collector. Instructors were briefed on the requirement for standardization during training and testing. All training and testing was conducted individually.

Students were tested on their ability to troubleshoot three problems (#10, #11, and #12) on the Grumman simulator (whose feedback capability had been disabled for the testing session). All students had previously received direct training on one of these problems, while the other two problems had not been previously trained. Table 15 shows the training and testing design at Fort Bliss. In addition to performing troubleshooting activities associated with these problems on the simulator, students also "walked through" a high voltage problem on the Hawk radar operational equipment (i.e., verbally indicating to the instructor appropriate procedures to be followed for each troubleshooting activity). Three non-troubleshooting tasks were also involved in the evaluation:

o Component location (written) - Students were given a blank block diagram and were asked to match component names with their locations.

o Component location (oral) - Students were asked to indicate the locations of 10 components on the radar, and were then asked to provide the names of 10 components indicated by the instructor.

o Weekly check procedures on the radar equipment.

Training and testing sessions were interspersed as shown in Table 15.

Students completed the Grumman simulator-based instruction at their own pace. Training and testing time averaged three days per student. Students were allowed to take as much time as needed to complete the written component location test, however, a time limit of one hour was imposed for completion

Table 15

Training and Testing Sequence for Grumman Simulator at Fort Bliss

Training	Testing
Simulator-based training segment: 1. AMTESS Introduction 2. HV Circuits - Games 3. Weekly HV Checks 4. Indicator Relationships - Diagram	
	A. Component location test (written)
5. Troubleshooting Last Good/ First Bad 6. HVPS Test Set 7. HVPS Procedures 8. Problem - MO Fil PS A4 9. Problem - PA High Voltage PS A2 10. Introduction to Troubleshooting 11. Problem - HV Regulator	
	B. Troubleshooting on the simulator (Simulator Segment 12): Fault 11 - MO High Voltage PS A1 Fault 10 - HV Regulator Fault 12 - PA Fil PS A3
13. Weekly Check Procedure	
	C. Component location tests (oral - on the operational equipment) D. Weekly check procedure E. High voltage "walk through" problem on the operational equipment

of each of the three troubleshooting problems. A five-minute time limit was observed for each of the two sections of the oral component location tests. No time limit was imposed on the weekly check procedures or the high voltage "walk through" problem.

Results

Trainee characteristics for Grumman and Seville/Burtek simulator-trained students at Fort Bliss are presented in Table 16. Mann-Whitney U-tests revealed that students who were trained on the Grumman simulator were older, $U = 23.5$, $p<.05$, and more experienced, $U = 1$, $p<.001$, than were students who were trained on the Seville/Burtek simulator (Experiment 5). This fact must be kept in mind when comparing the performance of students trained on these two simulators.

Written and Oral Tests. Table 17 provides descriptive statistics for the percentage of steps passed and for time required to complete the written test and the two oral tests.

Tests Conducted on the Simulator. Descriptive statistics for percentage of steps passed and for time to complete the troubleshooting problems on the simulator are presented for the Grumman simulator-trained students in Table 18.

Tests Conducted on the Operational Equipment. Percentage of performance test steps passed for the weekly check procedures and for the high voltage problem are presented in Figure 32 for students trained on the Grumman simulator as well as for students trained on the Seville/Burtek simulator. A series of 11 two-tailed Mann-Whitney U-tests revealed no significant differences among student performance in the two training conditions on these measures.

Time required to complete the weekly check procedure and for completing the high voltage problem is presented in Figure 33 for both groups of students (i.e., those trained on the Grumman simulator and those trained on the Seville/Burtek simulator). Here a series of 11 Mann-Whitney U-tests revealed that students trained on the Seville/Burtek simulator performed faster than did students trained on the Grumman simulator for the check nulling function task (weekly check #6), $U = 22.5$, $p<.05$; whereas students trained on the Grumman simulator performed the high voltage problem, $U = 7.5$, $p<.001$, faster than did students trained on the Seville/Burtek simulator.

Discussion

The results of the written and oral tests administered to students trained on the Grumman simulator at Fort Bliss clearly indicated that the students had mastered the names and locations of various components of the radar transmitter. The students also appeared to be capable of effectively troubleshooting high voltage problems on the simulator. The extent to which this troubleshooting skill transfers to operational equipment is unknown, however, because School constraints prevented testing on operational

Table 16

Characteristics of Trainees Involved in Experiment 6

Characteristic	Grumman Trainees	Seville/Burtek Trainees
Age:		
Mean	27.3	23
Standard Deviation	4.83	3.20
Grade: Range	E4-E7	E2-E3
Time in Service:		
Mean	7.55 years	8.7 months
Standard Deviation	4.55 years	.67 months
ASVAB Scores:		
Mechanical Maintenance		
Mean	109.11	108.1
Standard Deviation	18.17	10.29
General Technical		
Mean	112.11	115.6
Standard Deviation	13.50	8.04
Electronics		
Mean	114.22	113.8
Standard Deviation	13.91	8.4

Table 17

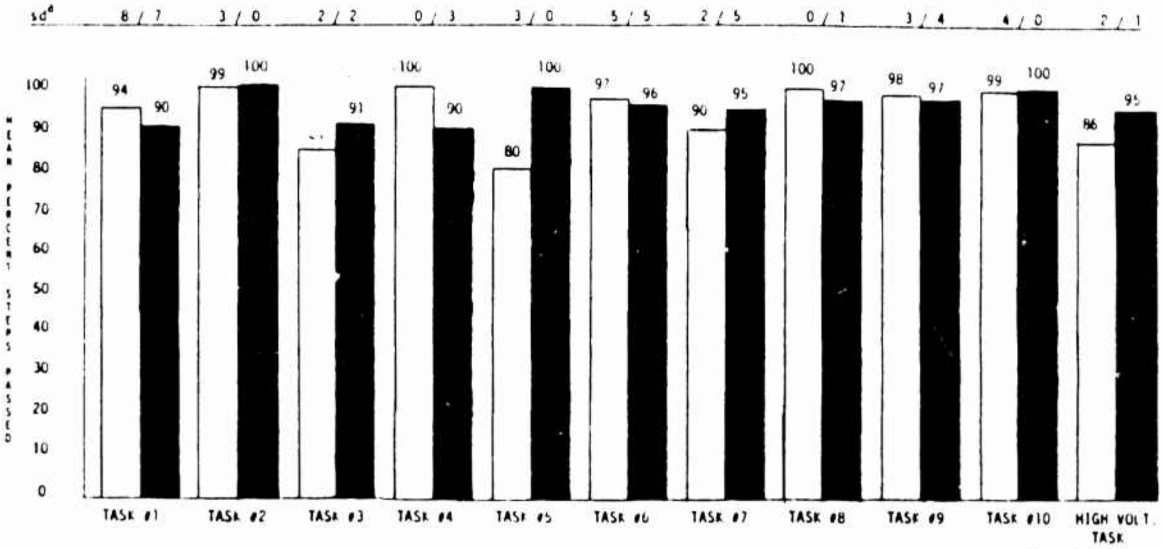
Descriptive Statistics for Written and Oral Exams
Administered to Grumman Trainees

	Percent Steps Correct		Time to Complete Test	
Exam	Mean	Standard Deviation	Mean	Standard Deviation
Written Test	84.9	16.2	16.7	11.12
First Oral Test	95	8.5	2.3	.48
Second Oral Test	89	9.94	2.3	1.06

Table 18

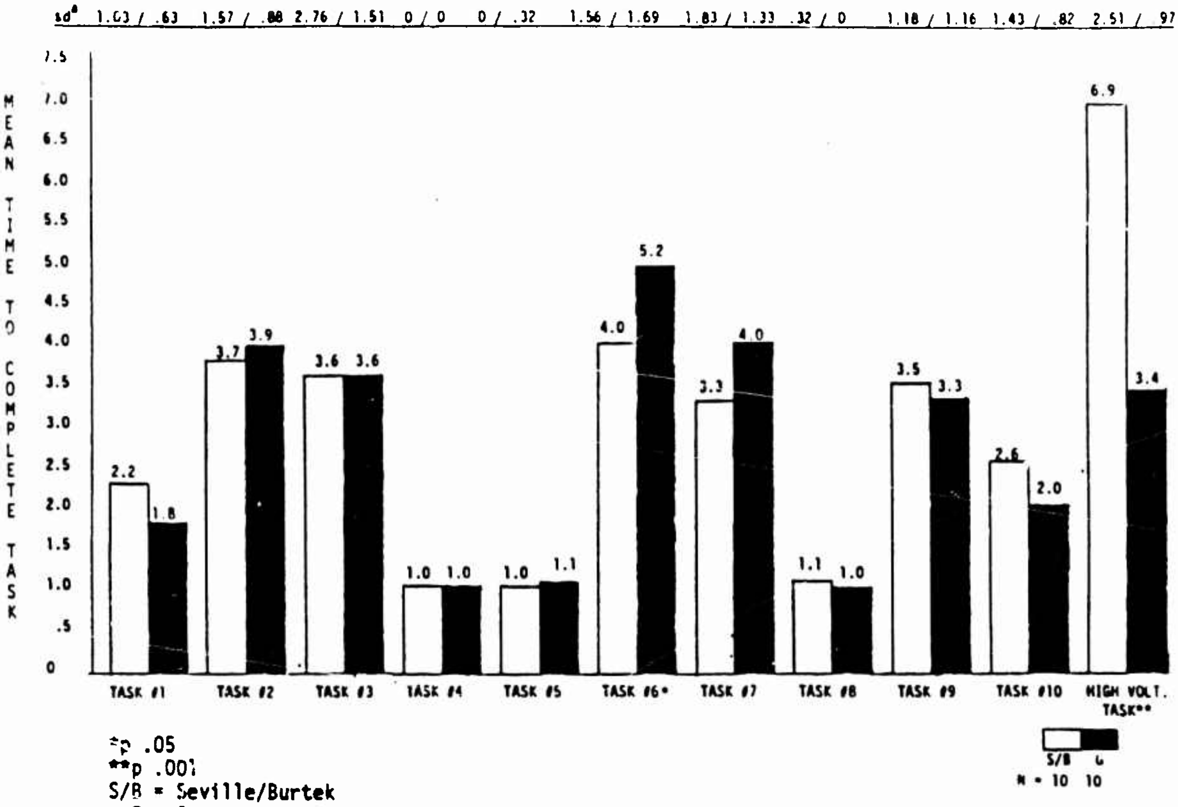
Descriptive Statistics for Percent Steps Passed
and Time to Complete Task on the Grumman Simulator

	Time to Complete (Minutes)	
Task	Mean	Standard Deviation
#10 - High Voltage Regulator Failure	21.8	4.94
#11 - MO High Voltage Power Supply A1 Failure	23.9	3.9
#12 - PA Filament Power Supply A3 Failure	7	2.06



S/B = Seville/Burtek
G = Grumman
[a]sd = Standard Deviation

Figure 32. Mean percent steps passed by students trained on the Seville/Burtek or Grumman simulator - weekly check and high voltage problem.



*p .05
**p .001
S/B = Seville/Burtek
G = Grumman
[a]sd = Standard Deviation

Figure 33. Mean time to complete task by students trained on the Seville/Burtek or Grumman simulator - weekly check procedure and high voltage problem (minutes).

equipment due to the danger involved in performing this task on high voltage equipment. When Grumman simulator-trained students "walked through" a high voltage problem, however, they did so competently.

Comparison of the performance of students trained on the Grumman simulator against the performance of students trained on the Seville/Burtek simulator revealed no differences between the two groups of nine of the 11 subtasks tested. For the two tasks where differences were noted, the Grumman simulator-trained students took longer to perform weekly check #6 (check nulling function), while the Seville/Burtek simulator-trained students took longer to perform the high voltage walk-through problem.

It seems possible that the difference between the two groups for the high voltage problem occurred because the Grumman simulator-trained students had much more experience troubleshooting than did the Seville/Burtek simulator-trained students. This difference in experience may also explain why the Grumman simulator-trained students took more time to perform weekly check #6 (check nulling function). This task required students to adjust several meters that were out of the normal range.

The Grumman simulator-trained students may have attempted to identify the underlying cause of the bad readings (weekly check #6) and they may have spent additional time ensuring that the meters were reading correctly. The Seville/Burtek simulator-trained students, on the other hand, may have simply performed the task as required by the written procedures without attempting to determine the cause of the faulty reading.

The high voltage problem, on the other hand, did not require students to ensure that meters were reading correctly. Further, the nature of the task prevented students from attempting to determine (by manipulating controls) the underlying cause of the problem. Instead, both groups of students simply read through a set of procedures and indicated the location and function of appropriate components to the instructor. The Grumman simulator-trained students may have been able to complete this task faster than the Seville/Burtek simulator-trained students since they were more familiar with the radar unit.

DISCUSSION AND CONCLUSIONS

The AMTESS training effectiveness evaluation included six separate study efforts. In this section an attempt is made to draw overall conclusions from the results of these studies. Before beginning, however, it is useful to understand that the purpose of the AMTESS evaluation is not merely to evaluate two specific training devices, but rather to assess an overall approach to maintenance training, which includes the entire process of specifying, designing, and implementing generic maintenance training devices. The AMTESS project has a long history (documented in detail by Criswell, Unger, Swezey, & Hays, 1983; and by Woelfel, Duffy, Unger, Swezey, Hays, & Mirabella, 1984). The conclusions drawn from the training effectiveness evaluation are, therefore, only one portion of the AMTESS evaluation. Final conclusions about the overall AMTESS program will await the synthesis of several reports and the continued development of the AMTESS concept.

Overview of Results

In all cases, the students trained on the AMTESS devices did, in fact, learn to perform the assigned tasks. All subjects (both simulator-trained and conventionally trained) passed the Schools' proficiency requirements. Analysis of the E/C and C/E ratios that were computed for five of the six experiments provides insight into the effectiveness of the AMTESS devices. (E/C and C/E ratios could not be computed for Experiment 6.) Mean E/C and C/E ratios for each of the experiments are presented in Table 19.

Table 19

Mean E/C and C/E Ratios for Data Collected during AMTESS Evaluation

Experiment Device MOS	1 S/B[a] 63B30	2 S/B 63W10	3 G[b] 63H30	4 G 63D30	5 S/B 24C10	Grand Mean
E/C ratio for percent steps passed	98	87	95	91	89	92
C/E ratio for time to complete task	72	52	86	74	75	71.8
C/E ratio for data collector interventions	71	49	131	60		77.8
E/C ratios for instructor ratings					85	
E/C ratios for school administered exams					99	

[a]S/B = Seville/Burtek

[b]G = Grumman

Mean E/C ratios for percentage of performance test steps passed were very high for all five experiments. The grand mean E/C ratio for this measure (collapsing across experiments) was 92. Clearly then, students who were trained on the curricula supporting the AMTESS devices performed very near the level of the students who were trained conventionally (in terms of percentage of performance test steps passed). This very high level of performance contrasts with the somewhat lower C/E ratios obtained for the time to complete task measures and the data collector intervention measure. The grand mean C/E ratio for the time to complete task measure was 71.8, while the grand mean C/E ratio for the data collector intervention measures (for four experiments) was 77.8. While these two C/E ratios indicate moderately good performance by the simulator-trained students, they are substantially

lower than the E/C ratios for percentage of performance test steps passed. This difference between the E/C ratio and the two C/E ratios may indicate the existence of a so-called "ceiling effect" (i.e., the tasks may have been relatively easy to perform. If the tasks had been more difficult, the E/C ratio for percentage of performance test steps passed may have decreased to the level of the two C/E ratios described above.

Inspection of Table 19 indicates that the lowest E/C and C/E ratios for each of the three primary dependent variables were obtained by the 63W10 students. An outstanding characteristic of these students is their lack of experience. These students had recently completed basic training and were unfamiliar with the use of Army TMs, tools, troubleshooting procedures, etc. During conventional training sessions, the 63W10 students were able to familiarize themselves with the M809 vehicle and various Army procedures. On the other hand, the simulator-trained students received their first exposure to Army equipment and procedures during the performance test. Although all of the simulator-trained 63W10 students passed the School's proficiency requirements, the relatively low E/C and C/E ratios exhibited by these students may have been caused by their lack of familiarity with operational equipment and procedures. If this hypothesis is correct, then the effectiveness of the AMTESS device may be improved if it is used as an adjunct to conventional training rather than as a substitute for conventional training for inexperienced students.

The results of the significance tests (t-tests and Mann-Whitney U-tests) performed for each of the experiments parallel the trends for the E/C and C/E ratio scores. Table 20 presents the percent of significance tests which indicated superior performance by the conventionally trained students across five experiments. It is noteworthy that over 50% of the comparisons conducted in Experiment 2 (MOS 63W10) indicated superior performance by conventionally trained students. All other experiments yielded fewer statistically significant comparisons. Also, the time to complete task measure yielded the greatest proportion of statistically significant comparisons (53%) in favor of conventional instruction.

Approximately 30% of all comparisons indicated statistically superior performance by conventionally trained students. In most of these cases, however, inferior performance by the simulator-trained students should not be attributed to the conceptual approach underlying the AMTESS device. Rather, the deficiencies are the end result of decisions made by the device manufacturers when front-end analysis activities were performed. For example, the curriculum associated with the Seville/Burtek device does not emphasize the use of TMs or set-up and check-out of STE/ICE. Evidently, when the task analysis and training requirements analysis were conducted, these activities were not identified as critical tasks. The failure to include these in the curriculum tasks eventually resulted in the low transfer-of-training scores presented in this report.

Another example of this sort involves certain remove/replace activities associated with the Grumman device at APG. Students trained on the Grumman simulator are not required to remove and replace certain components (i.e., the voltage regulator) that have been identified as faulty. Rather, they were simply required to indicate that they had identified the faulty component. The simulator presented a message to students indicating that the faulty

Overview of Results

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Mean E/C and C/E Ratios for Data Collected during AMTESS Evaluation

Experiment Device MOS	1 S/B[a] 63B30	2 S/B 63W10	3 G[b] 63H30	4 G 63D30	5 S/B 24C10	Grand Mean
E/C ratio for percent steps passed	98	87	95	91	89	92
C/E ratio for time to complete task	72	52	86	74	75	71.8
C/E ratio for data collector interventions	71	49	131	60		77.8
E/C ratios for instructor ratings					85	
E/C ratios for school administered exams					99	

[a]S/B = Seville/Burtek

[b]G = Grumman

Mean E/C ratios for percentage of performance test steps passed were very high for all five experiments. The grand mean E/C ratio for this measure (collapsing across experiments) was 92. Clearly then, students who were trained on the curricula supporting the AMTESS devices performed very near the level of the students who were trained conventionally (in terms of percentage of performance test steps passed). This very high level of performance contrasts with the somewhat lower C/E ratios obtained for the time to complete task measures and the data collector intervention measure. The grand mean C/E ratio for the time to complete task measure was 71.8, while the grand mean C/E ratio for the data collector intervention measures (for four experiments) was 77.8. While these two C/E ratios indicate moderately good performance by the simulator-trained students, they are substantially

component has been replaced, and the lesson continued. Evidently, when the Grumman device was designed (as an adjunct to conventional training), the decision was made to exclude hands-on removal/replacement of the voltage regulator from the curriculum. It should come as no surprise to find that conventionally trained students (who physically remove and replace the voltage regulator during training) may perform this task better than conventionally trained students.

Conclusions

It seems clear that students trained on the AMTESS devices were able to competently perform a variety of maintenance activities (both procedural and perceptual-motor tasks) for widely differing applications (both electronic and mechanical equipment). It is equally clear, however, that the devices as presently configured are inferior to conventional training methods. Students trained on the curricula associated with the AMTESS devices required significantly greater amounts of time to complete tasks and significantly greater numbers of data collector interventions to complete tasks. Although simulator-trained student performance was also inferior to conventionally trained student performance in terms of percentage of performance steps passed, E/C ratios indicated that performance by the two groups was comparable.

The effectiveness of the AMTESS devices varies by task type and student skill level. A program of controlled laboratory research is required in order to identify those situations in which the devices can be used most effectively.

The utility of future evaluations of AMTESS devices (or other training devices) can be enhanced if the following recommendations are followed:

- The objective of the evaluation should be clearly defined and understood by all parties involved in the effort.

- A clear line of communication should be established between the individuals conducting the evaluation and the individuals who control resources essential to the success of the evaluation (personnel, equipment, facilities, etc.).

- Individuals who control essential resources must understand the importance of experimental rigor to the success of the effort.

The major conclusion from this study is that the concept of a modular design approach to maintenance training devices is workable. Detailed analyses which closely match task demands to device design can, however, dramatically improve the quality of training available from this type of training device (see Woelfel, Duffy, Unger, Swezey, Hays, & Mirabella, 1983). Additionally, care must be taken to integrate formally the training devices into Army School curricula in order to maximize training benefits that may be derived from such devices.

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APPENDIX A

PERFORMANCE TESTS USED IN EXPERIMENT 1

ORIGINAL SCHOOL PERFORMANCE TEST
FOR 63B30 STUDENTS

US ARMY ORDNANCE CENTER AND SCHOOL
Aberdeen Proving Ground
Maryland

610-63B30-F22-PT
Sep 81

PERFORMANCE TEST

TASK:

Replace Alternator Drive Belts.

TEST ORIENTATION:

During this test you will be required to replace the alternator drive belts on an M809 series vehicle; observe safety and maintenance discipline rules; pick and use maintenance publications, forms and tools.

TEST CONDITIONS:

You will be working in an automotive maintenance shop with a TM library and tool room available for your use.

MATERIALS/TOOLS/EQUIPMENT:

M809 series vehicle, DA Form 2404 indicating defective alternator drive belts, and necessary tools and equipment.

PERFORMANCE MEASURE 1:

You will be tested on replacing the alternator drive belts.

DID THE STUDENT/DID YOU:

	GO	NO GO	GO	NO GO	GO	NO GO	INIT
1. Select and use correct TM's?							
2. Select and use tools correctly?							
3. Correctly replace and adjust alternator drive belts IAW appropriate TM?							
4. Correctly install and adjust the fan drive belts IAW appropriate TM?							

US ARMY ORDNANCE
CENTER AND SCHOOL
Aberdeen Proving Ground
Maryland

610-63B30-F23-PT
Feb 82

PERFORMANCE TEST

TASK:

Remove and replace starter

TEST ORIENTATION:

During this test you will be required to remove and replace the starter on an M809 series vehicle, observe all safety rules; pick and correctly use necessary tools and equipment, complete DA Form 2404.--

TEST CONDITIONS:

You will be working in a maintenance shop and you can use the technical manual.

MATERIAL/TOOLS/EQUIPMENT:

M809 series vehicle, GM tool kit, chock blocks, 1/2 inch rope, tags torque wrench, replacement starter.

PERFORMANCE MEASURE 1

You will be tested on your ability to select and use the correct tools and TM's; observe all safety rules and practice good work habits throughout the test.

ATTEMPT	1st		2nd		3rd		
DID THE STUDENT/DID YOU:	GO	NO GO	GO	NO GO	GO	NO GO	INIT
1. Select correct publications and paragraphs?							
2. Remove all jewelry before starting tasks?							
3. Select and use tools correctly?							
4. Maintain a clean safe work area?							
5. Perform work without causing damage to equipment or injury to personnel?							

DID THE STUDENT/DID YOU:	ATTEMPT 1st GO	1st NO GO	2nd GO	2nd NO GO	3rd GO	3rd NO GO	INIT
8. Replace leads correctly?							
9. Connect battery ground?							
10. Perform operational check?							
11. Complete DA Form 2404?							

US ARMY ORDNANCE
CENTER AND SCHOOL
Aberdeen Proving Ground
Maryland

610-63B30-F25-PT
Feb 82

PERFORMANCE TEST 1

TASK:

Troubleshoot engine malfunction.

TEST ORIENTATION:

During this test you will be required to troubleshoot the engine on the M809 series vehicle, observe all safety rules, pick and correctly use necessary tools and equipment, complete DA Form 2404.

TEST CONDITIONS:

You will be working in a maintenance shop and you can use the TM.

MATERIALS/TOOLS/EQUIPMENT:

M809 series vehicle, GM tool set creeper, chock blocks, rags, DA Form 2404.

PERFORMANCE MEASURE 1

You will be tested on your ability to select and use the correct tools and TM's; observe all safety rules and practice good work habits and troubleshoot the engine for malfunction.

DID THE STUDENT/DID YOU:

ATTEMPT	1st GO	1st NO GO	2nd GO	2nd NO GO	3rd GO	3rd NO GO	INIT
1. Select correct publications and paragraphs?							
2. Remove all jewelry before starting task?							
3. Select and use tools correctly?							
4. Maintain clean work area?							

US ARMY ORDNANCE
CENTER AND SCHOOL
Aberdeen Proving Ground
Maryland

610-63B30-F5-PT
Feb 82

PERFORMANCE TEST

TASK

Troubleshoot electrical system; test charging and starter circuits.

TEST ORIENTATION

During this test you will be required to troubleshoot the electrical system and test the charging and starting circuits on a M151A1/A2 series vehicle using the multimeter and STE/ICE test set, and complete DA Form 2404 in accordance with appropriate TM's.

TEST CONDITIONS

In an organizational shop environment.

EQUIPMENT

An M_809 series vehicle, general mechanic's tool kit, multimeter, STE/ICE test set, DA Form 2404, pencil and appropriate references.

PERFORMANCE MEASURE 1

You will be tested on the selection and use of TM's, tools, workmanship and safety. All items or questions listed in this performance measure will be used to evaluate you throughout this test.

DID THE STUDENT/DID YOU:

ATTEMPT	1st GO	1st NO GO	2nd GO	2nd NO GO	3rd GO	3rd NO GO	INIT
1. Select proper TM and references?							
2. Select proper tools?							
3. Use tools correctly?							
4. Remove all jewelry?							
5. Maintain a clean work area?							

STUDENT NOTE: Stop. Have instructor verify your work before going to the next performance measure.

PERFORMANCE MEASURE 4

You will be tested on troubleshooting the electrical system on a M809 series vehicle using the multimeter and completing DA Form 2404.

DID THE STUDENT/DID YOU:	ATTEMPT	1st		2nd		3rd		
		GO	NO GO	GO	NO GO	GO	NO GO	INIT
1. Zero the multimeter?								
2. Zero the multimeter after each use?								
3. Troubleshoot the lighting or directional signal and electrical system?								
4. Identify the malfunctions?								
5. Complete DA Form 2404?								

REVISED PERFORMANCE TEST FOR 63B30 STUDENTS

SUBJECT # ____

MOS 63B30 PERFORMANCE MEASURES

I. BACKGROUND DATA

STUDENT NAME: ______________________ CLASS # ____ GROUP # ____

GRADE: (E-4, E-5, E-6, E-7, other) ____

INSTRUCTOR (Classroom) __________ INSTRUCTOR (Testing) __________

EXP. CONDITION: Conventional ____ Experimental ____

DATE: ___/___/ 83 TIME STARTED: ________

ATTEMPT #: 1 ___ 2 ___ 3 ___ GRADE: Pass ___ Fail ___

GO	NO GO		COMMENTS
		II. ADJUST ALTERNATOR DRIVE BELTS	
		TIME STARTED ________	
__	____	1. Select TM 9-2320-260-20-3-1.	
__	____	2. Select chapter 7, page 9.	
		TIME FINISHED ______	
		TIME STARTED ________	
__	____	1. Pull alternator out away from engine. prybar (1).	
__	____	2. Place a straight edge (2) on alternator pulley (3) and drive pulley (4).	
__	____	3. Press down on center of both belts and measure distance at arrows. 1/8" to 1/4"	
__	____	4. Tighten bolt. (6) 9/16" wrench	
__	____	5. Hold two bolts (8) 5/8" wrench, and tighten 2 nuts [(7) 11/16" wrench] on bolts.	
__	____	6. Place a straight edge (2) on alternator pulley (3) and driver pulley (4).	
__	____	7. Press down on center of both belts and measure distance at arrows. 1/8" to 1/4"	
		TIME FINISHED _______	

GO	NO GO		COMMENTS
		III. STARTER MOTOR REMOVAL AND REPLACEMENT	
		TIME STARTED _______	
_	___	1. Select TM 9-2320-260-20-3-1.	
_	___	2. Select Starting System, 7-26.	
		TIME FINISHED _______	
		A. DISCONNECT BATTERY GROUND AT FRAME	
		TIME STARTED _______	
_	___	1. Lift 2 handles (4) and pull box (5) out onto step (6).	
_	___	2. Using wrench, unscrew and take off nut (1).	
_	___	3. Take off ground cable (2). Move cable out of the way so there is no chance it will touch batteries.	
		TIME FINISHED _______	
		B. REMOVAL	
		TIME STARTED _______	
_	___	1. Tag Leads	
_	___	2. Using screwdriver, unscrew and take out screw (1). Take off lead (2).	
_	___	3. Using 3/4" wrench, unscrew and take off nut with washer (3). Take off 2 leads (4).	
_	___	4. Using 3/4" wrench, unscrew and take off nut with washer (5). Take off 2 leads (6).	
		SOLDIER A	
_	___	5. Tie rope (1) around starter motor (2). Stand on fender and using rope sling, hold up starter motor while Soldier B takes out mounting screws.	
		SOLDIER B	
_	___	6. Using 15/16" socket with ratchet and extension, unscrew and take out 2 screws with washers (3).	

GO	NO GO		COMMENTS
		SOLDIER B	
___	___	7. Using 9/16" 12-point socket with ratchet and extension, unscrew and take out capscrew with washer (4) underneath starter motor (2).	
___	___	8. Slide starter motor (1) out of flywheel housing (2) while Soldier A holds rope sling for support.	
___	___	9. Take off spacer (4).	
		SOLDIER A	
___	___	10. Using rope sling (1), carefully lower starter motor (2).	
		SOLDIER B	
___	___	11. Guide starter motor (2) down between propeller shaft (3), spring hanger (4), and crossmember (5) to floor.	
___	___	12. Untie rope sling (1).	
		TIME FINISHED ______	
		C. REPLACEMENT	
		TIME STARTED ______	
___	___	1. Select TM 260-20-3-1, pg. 7-30.	
		SOLDIER A	
___	___	2. Tie rope around starter motor. Stand on fender and raise and hold up starter motor as Soldier B guides it into place.	
		SOLDIER B	
___	___	3. Guide starter motor up between propeller shaft spring hanger and crossmember.	
___	___	4. Put 2 screws with washers (1) in starter motor (2).	
___	___	5. Put flat sided gasket on (3).	
___	___	6. Put spacer (4) on screws (1).	
___	___	7. Put on round gasket.	
___	___	8. Slide starter motor (2) into opening in flywheel housing (6).	
___	___	9. Using 15/16" socket with ratchet and extension, screw in and tighten 2 screws with washers (1).	
___	___	10. Untie rope sling.	

GO	NO GO		COMMENTS
		SOLDIER A	
___	___	11. Take away rope sling.	___
		SOLDIER B	___
___	___	12. Using 9/16" 12-point socket with ratchet and extension, screw in and tighten screw with washer (1).	___
___	___	13. Using torque wrench, tighten screw (1) and 2 screws (2) to 80 to 110 pound feet.	___
___	___	14. Put on 2 leads (1) as tagged. Using 3/4" wrench, screw on and tighten nut with washer (2).	___
___	___	15. Put on two leads (3) as tagged. Using 3/4" wrench, screw on and tighten nut with washer (4).	___
___	___	16. Put on lead (5) as tagged. Using screwdriver, screw in and tighten screw with washer (6). Take off tags.	___
		TIME FINISHED ____	___
		D. RECONNECT BATTERY GROUND	___
		TIME STARTED ____	___
___	___	1. Select reconnect battery ground. Pg. 7-254.	___
___	___	2. Put terminal of ground cable (1) on screw (2).	___
___	___	3. Using wrench, screw on and tighten nut (3).	___
___	___	4. Push box (1) back under cab.	___
		TIME FINISHED ____	___
		END OF TASK	___

GO NO GO COMMENTS

IV. INDUCED MALFUNCTION OIL PUMP FAILURE TROUBLESHOOTING ENGINE MALFUNCTION

TIME STARTED ______

__ ____ 1. Determine malfunction.

TIME FINISHED ______

TIME STARTED ______

__ ____ 1. Select TM 9-2320-260-20-2-1, pg. 6-2.

__ ____ 2. Select low or no oil pressure, pg. 8-2.

A. CHECK OIL PRESSURE GAUGE PIPING AND FITTING.

__ ____ 3. Signs of leaking oil.

__ ____ 4. Bent, cracked or broken piping.

__ ____ 5. Loose fittings.

B. CHECK SERVICE ABILITY OF OIL PRESSURE GAUGE (Describe to instructor using TM AS NEEDED). NOTE CAUTION.

__ ____ 6. Remove oil pressure pipe.

__ ____ 7. Screw on test gauge. 16 PSI.

__ ____ 8. Start engine.

__ ____ 9. Refer to 260-10-2, pp. 1-16. (15 to 20 PSI).

__ ____ 10. See if test gauge pressure is higher. (If reading stays low, tell direct support.)

TIME FINISHED ______

GO NO GO COMMENTS

V. INSPECT ELECTRICAL SYSTEM

TIME STARTED ______

GO	NO GO		COMMENTS
___	___	1. Select TM 9-2320-2-1.	
___	___	2. Select all truck electrical systems that do not work (symptom 59, pg. 24-378).	

TIME FINISHED ______

A. CHECK 4 BATTERIES FOR DAMAGE.

TIME STARTED ______

GO	NO GO		COMMENTS
___	___	1. Lift 4 handles (4) and pull 2 battery boxes (5) out onto step (6).	
___	___	2. See if any of the 4 battery cases are broken, cracked or distorted.	
___	___	3. See if any of the 8 battery terminal posts are loose.	
___	___	4. Check that batteries and cables are installed correctly.	
___	___	5. Check for corrosion on batteries, cable clamps or terminal posts.	
___	___	6. Check for loose battery terminal connections.	
___	___	7. Check all battery cables for cracked insulation or bare wires.	

TIME FINISHED ______

B. CHECK BATTERY ELECTROLYTE LEVEL AND FOR IMPURITIES.

TIME STARTED ______

GO	NO GO		COMMENTS
___	___	1. Unscrew and lift off 24 battery filler caps.	
___	___	2. Look into 24 openings and see if electrolyte level is above top of plates. Level should be above plates in each opening.	
___	___	3. Look into all battery openings. There should be no dirt, oil or other impurities on top of electrolyte.	

TIME FINISHED ______

GO NO GO

COMMENTS

ELECTROLYTE LEVEL & IMPURITIES CHECK

TIME STARTED ______

— ——— 1. Screw 24 filler caps on batteries.

— ——— 2. Using battery charger, charge each battery separately. Refer to TM 9-6140-200-12.

TIME FINISHED ______

C. MEASURE ELECTROLYTE SPECIFIC GRAVITY

TIME STARTED ______

a. PRELIMINARY CLEANING

— ——— 1. Swing back plastic cover (1) of battery tester (2) all the way.

— ——— 2. Using tissue, wipe bottom of plastic cover (1) and measuring window (3).

— ——— 3. Close plastic cover (1).

b. CHECKOUT PROCEDURE FOR EACH BATTERY CELL

— ——— 1. Unscrew and take off battery filler cap (1).

— ——— 2. Take <u>black</u> dip stick (2) from dip stick retainer (3).

— ——— 3. Put tip of dip stick (2) into battery cell (4).

— ——— 4. Take out dip stick (2) from battery cell (4).

— ——— 5. Using dip stick (2), place a few drops of electrolyte on measuring surface through opening in plastic cover (6).

— ——— 7. Read battery charge scale (3) on left side. Reading (4) is where dark shadow (5) meets light area (6).

— ——— 8. Reading (4) should be in GOOD range (1.250 to 1.300). If specific gravity is below 1.225, replace battery with a fully charged battery if recharging is not possible.

GO	NO GO		COMMENTS
		BATTERY CELL CHECKOUT	______
__	__	9. Using battery filler syringe, add distilled water if available or clean water as needed to bring electrolyte to needed level, 3/4" above plates.	______
__	__	10. Screw on and tighten battery filler cap (7).	______
__	__	11. Clean and dry all parts of coolant and battery tester (1).	______
		TIME FINISHED ______	______
		D. TESTING ELECTRICAL SYSTEM	______
		TIME STARTED ______	______
__	__	1. Set battery switch to ON.	______
__	__	2. Read battery generator indicator. (Indicator needle should be between mid-yellow and low-green.)	______
__	__	3. Set BATTERY switch to OFF.	______
__	__	4. Disconnect battery ground cable. Refer to Vol. 3, chapter 7, paragraph 7-59.	______
__	__	5. Pull 81 lead off BATTERY switch.	______
__	__	6. Reconnect battery ground cable. Refer to Vol. 3, chapter 7, paragraph 7-59.	______
__	__	7. Push in both battery boxes. Refer to Vol. 3, chapter 7, paragraph 7-57.	______
		TIME FINISHED ______	______
		E. PERFORM VTM HOOKUP AND CHECKOUT	______
		TIME STARTED ______	______
__	__	1. Select TM 9-4910-571 12 and P.	______
__	__	2. Select pg. 2-23.	______
__	__	3. Pull ~~off~~ the power switch on the VTM.	______
__	__	4. Connect P1 of the power cable W5 to J1 on the VTM. E-15	______
__	__	5. Connect the red clip lead of cable W5 to the positive terminal of the vehicle battery.	______

GO	NO GO		COMMENTS
		VTM HOOKUP & CHECKOUT	
___	___	6. Connect the black clip lead of cable W5 to the negative terminal of the vehicle battery.	
___	___	7. Push on the power switch on the VTM.	
___	___	8. Verify that display indicates .8.8.8.8 for 2 seconds and then changes to -----.	
___	___	9. Dial 66 into test select and press test. 2-25.	
___	___	10. Verify that VTM displays and holds "0066."	
___	___	11. Dial test select to 99 and press test.	
___	___	12. Verify that VTM displays "pass."	
___	___	13. Dial 60 into test select and press test. Veh. Test Card E-15.	
___	___	14. When "VEH" appears, dial "10" into test select.	
___	___	15. Press test switch and ensure VTM displays "10."	
		TIME FINISHED ______	
		F. DC VOLTAGE TEST	
		TIME STARTED ______	
___	___	1. Select pg. 2-27.	
___	___	2. Attach P1 of test probe cable W2 to J4 of VTM.	
___	___	3. Short red and black clip leads of W2 together.	
___	___	4. Dial 89 into test select.	
___	___	5. Press and hold "TEST" until "CAL" appears.	
___	___	6. Release "TEST."	
___	___	7. Ensure offset value within limits (-6.8 to +6.8).	
___	___	8. Connect the red clip lead to the voltage test point. This is the positive (+) point if a (+) voltage is being tested.	

GO	NO GO		COMMENTS
		DC VOLTAGE	
_	___	9. Connect the black clip lead to ground.	
_	___	10. Turn ON the circuit if voltage is not already present.	
_	___	11. Press TEST.	
_	___	12. If VTM reads .9.9.9.9, voltage measured is greater than 45 volts.	
_	___	13. The displayed value is the test result. E-15.	
		TIME FINISHED ______	
		G. CHECK BATTERY SWITCH LEAD 459	
		TIME STARTED ______	
_	___	1. Push lead 81 back into BATTERY switch.	
_	___	2. Pull lead 459 lead off BATTERY switch. Set BATTERY switch to ON.	
	___	3. Connect the red clip lead to the voltage test point. This is the positive (+) point if a (+) voltage is being tested.	
_	___	4. Connect the black clip lead to ground.	
_	___	5. Turn ON the circuit if voltage is not already present.	
_	___	6. Press TEST.	
_	___	7. If VTM reads .9.9.9.9, voltage measured is greater than 45 volts.	
_	___	8. The STE/ICE should indicate 24 volts. E-15.	
_	___	9. Correctly interpret reading.	
		TIME FINISHED ______	

APPENDIX B

PERFORMANCE TESTS USED IN EXPERIMENT 2

ORIGINAL SCHOOL PERFORMANCE TEST FOR 63W10 STUDENTS

US ARMY ORDNANCE
CENTER AND SCHOOL
Aberdeen Proving Ground
Maryland

AMTESS Evaluation
Part I
Apr 82

PERFORMANCE TEST

TASK: Troubleshoot Engine Lubricating System

TEST ORIENTATION:

During this test you will be required to troubleshoot an engine to determine the cause of a malfunction in the engine lubrication system; select and use proper maintenance publications, forms, and tools.

TEST CONDITIONS:

You will be working in a maintenance shop with publications and tools/equipment available in library and tool room.

MATERIALS/TOOLS/EQUIPMENT:

Operational M809 series vehicle or NHC 250 Cummins engine DA Form 2404 indicating engine lubrication system defective.
Publications
Tools/Equipment

PERFORMANCE MEASURES:

You will be tested on how well you accomplish the following steps.

DID THE STUDENT/DID YOU:	GO	NO GO	GO	NO GO	GO	NO GO	INIT.
1. Determine malfunction (symptom)?							
2. Select and use correct TMs?							
3. Select and use correct tools?							
4. Check oil pressure piping and fitting?							
5. Check serviceability of oil pressure gage?							
6. Inspect oil lines and fittings?							
7. Determine malfunctioning component?							
8. Observe safety and maintenance discipline rules?							

US ARMY ORDNANCE
CENTER AND SCHOOL
Aberdeen Proving Ground
Maryland

AMTESS Evaluation
Part II
Apr 82

PERFORMANCE TEST

TASK: Replace Engine Oil Pump

TEST ORIENTATION:

During this test you will be required to remove and install the engine oil pump of an M809 series vehicle engine; select and use proper maintenance publications, forms, and tools.

TEST CONDITIONS:

Same as Part I

MATERIALS/TOOLS/EQUIPMENT:

M809 Series vehicle with engine oil drained
Publications
Tools/Equipment

PERFORMANCE MEASURES:

You will be tested on how well you accomplish the following steps.

DID THE STUDENT/DID YOU:	GO	NO GO	GO	NO GO	GO	NO GO	INIT
1. Select and use the correct TMs?							
2. Select and use correct tools?							
3. Remove oil filter?							
4. Remove clamp securing hoses?							
5. Remove return hose?							
6. Remove pickup tube?							
7. Remove pickup hose?							
8. Leave elbows intact?							
9. Remove oil pump?							
10. Install replacement pump and gasket with all bolts in proper place according to length?							
11. Install pickup hose correctly?							
12. Install pickup tube correctly?							
13. Install return hose correctly?							
14. Secure hoses with clamps?							
15. Install oil filter?							
16. Understand procedure and reason for filling oil pump?							
17. Observe safety and maintenance discipline rules?							
18. Correctly complete DA Form 2404?							

REVISED PERFORMANCE TEST
FOR 63W10 STUDENTS

SUBJECT # _____

MOS 63 W 10 (WHEELED VEHICLE MECHANIC) PERFORMANCE MEASURES

I. BACKGROUND DATA

STUDENT NAME: ____________________ CLASS # ______ GROUP # ______

GRADE: (E-1, E-2, Other) ______

INSTRUCTOR (CLASSROOM) ____________________ TESTING ____________

EXP. CONDITION: CONVENTIONAL ______ EXPERIMENTAL ______

DATE: ____/____/82 TIME STARTED ____________

ATTEMPT # 1____ 2____ 3____ GRADE: PASS ____ FAIL ____

INDUCED MALFUNCTION OIL PUMP FAILURE

GO	NO GO		COMMENTS
		TROUBLESHOOTING ENGINE MALFUNCTION	
		TIME STARTED ____________	
___	___	1. Determine malfunction.	
		TIME FINISHED ____________	
		TIME STARTED ____________	
___	___	1. Select TM 9-2320-260-20-2-1, pg. 6-2.	
___	___	2. Select low or no oil pressure, pg. 8-2.	
		Check oil pressure gauge piping and fitting.	
___	___	3. Signs of leaking oil.	
___	___	4. Bent, cracked or broken piping.	
___	___	5. Loose fittings.	
		Check service ability of oil pressure gauge (describe to instructor using TM AS NEEDED). NOTE CAUTION.	
___	___	6. Remove oil pressure pipe.	
___	___	7. Screw on test gauge. 16 PSI	
___	___	8. Start engine.	
___	___	9. Refer to 250-10-2, pg. 1-16 (15 to 20 PSI).	
___	___	10. See if test gauge pressure is higher. If reading stays low, tail circuit support)	
		TIME FINISHED ____________	

DIRECT SUPPORT TROUBLESHOOTING

GO	NO GO	
		TIME STARTED ______
____	____	1. Select TM 9-2320-260-34-1.
____	____	2. Select low or no oil pressure, pg. 3-2.
____	____	3. Check for loose fittings.
____	____	4. Check for leaking hoses.
____	____	5. Check for broken pickup tube.
____	____	6. Are the above three in functioning order?
____	____	7. Correctly use manual to determine need for oil pump removal.
		TIME FINISHED ______
		OIL PUMP FILTER AND PUMP REMOVAL
		Removal
		TIME STARTED ______
____	____	1. Select TM 9-2320-34-2-1, pg. 3-182.
____	____	2. Select TM 9-2320-34-21, pg. 2-29 or TM 9-2320-260-20.
____	____	3. Remove center bolt. 9/16" wrench
____	____	4. Remove filter assembly.
____	____	5. Indicate throw away filter element and seal.
		TIME FINISHED ______
		Oil pump
		TIME STARTED ______
____	____	1. Select pg. 3-183.
____	____	2. Remove two bolts, washers, and hose clamps. 5/8" wrench.
____	____	3. Remove return hose. 1-1/4" and 1-1/2" wrenches.
____	____	4. Remove elbow tube. 1-1/4" wrench.
____	____	5. Remove pickup hose. 1-1/4" and 1-3/8" wrenches.
____	____	6. Remove four bolts and lockwashers. 5/8" wrench.
____	____	7. Remove one bolt (centerline). 5/8" wrench.
____	____	8. Remove oil pump and gasket.
____	____	9. Indicate throw away gasket.
		TIME FINISHED ______

SUBJECT #________

MOS 63 W 10

STUDENT NAME:____________

GO	NO GO		COMMENTS
		OIL PUMP FILTER AND PUMP REPLACEMENT	
		Replacement	
		TIME STARTED ____________	
___	___	1. Select TM 9-2320-260-34-2-1, pg. 3-196.	
___	___	2. Place gasket on pump body.	
___	___	3. Screw in and tighten two bolts and lockwashers to pump plate. 5/8" wrench.	
___	___	4. Screw in and tighten bolt and lock-washer (center line), 5/8" wrench.	
___	___	5. Screw in and tighten 6-1/2" bolt (very top) and lockwasher. 5/8" wrench.	
___	___	6. Screw in and tighten 7-1/2" bolt (bottom, behind filter) and lock-washer. 5/8" wrench.	
___	___	7. Replace pickup (short) hose. 1-1/4" and 1-3/8" wrenches	
___	___	8. Replace elbo tube. 1-1/4" wrench	
___	___	9. Replace return (long) hose. 1-1/4" wrench.	
___	___	10. Replace two clamps, bolts, washers. 5/8" wrench.	
___	___	11. Replace seal and filter element and assembly.	
___	___	12. Replace center bolt. 9/16" wrench	
		TIME FINISHED ____________	

APPENDIX C

PERFORMANCE TESTS USED IN EXPERIMENTS 3 AND 4

ORIGINAL SCHOOL PERFORMANCE TEST
FOR 63D30 and 63H30 STUDENTS

US ARMY ORDNANCE
CENTER AND SCHOOL
Aberdeen Proving Ground
Maryland

63H30-G7-WCT
Sep 82

WITHIN-COURSE TEST - FOR VALIDATION OF "AMTESS"

TASK:

Diagnosis of generating system for malfunctions (300 amp).

TEST ORIENTATION

During this test you will be required to diagnose a malfunctioning 300 amp charging system using an STE/ICE test set. Three hours is the most time you will be allowed to finish this test.

TEST CONDITIONS

You will be working in an organizational maintenance shop and you can use the TM.

MATERIALS/TOOLS/EQUIPMENT

M110 vehicle, F&E general mechanic's tool kit, STE/ICE test set.

PERFORMANCE MEASURE 1

You will be tested on how well you can make STE/ICE basic connections and tests.

DID THE STUDENT/DID YOU:

ATTEMPT	1st		2d		3d		
	GO	NO GO	GO	NO GO	GO	NO GO	INIT
1. VTM - general setup?							
2. VTM - checkout?							

STUDENT NOTE: STOP - Call instructor before proceeding.

PERFORMANCE MEASURE 2

You will be tested on testing generator output voltage at slave receptable.

DID THE STUDENT/DID YOU:

ATTEMPT	1st		2d		3d		
	GO	NO GO	GO	NO GO	GO	NO GO	INIT
1. Testing generator output voltage. a. Test voltage at slave receptable?							
b. Start engine and load circuits, then test again?							
c. Analyze results?							

STUDENT NOTE: STOP - Call the instructor before proceeding?

PERFORMANCE MEASURE 3

You will be tested on testing voltage at regulator wiring harness.

DID THE STUDENT/DID YOU:

ATTEMPT	1st		2d		3d		
	GO	NO GO	GO	NO GO	GO	NO GO	INIT
1. Test voltage at regulator wiring harness. a. Disconnect proper wiring harness?							
b. Place probes in proper sockets?							
c. Analyze results?							

STUDENT NOTE: STOP - Call instructor before proceeding.

PERFORMANCE MEASURE 4

You will be tested on testing voltage at regulator receptacle.

DID THE STUDENT/DID YOU:

ATTEMPT	1st		2nd		3rd		
	GO	NO GO	GO	NO GO	GO	NO GO	INIT
1. Test voltage at regulator receptacle?							
a. Disconnect proper wiring harness?							
b. Place probes in proper sockets?							
c. Analyze results							

STUDENT NOTE: STOP - Call instructor before proceeding.

PERFORMANCE MEASURE 5

You will be tested on your analysis of corrective action that must be taken.

DID THE STUDENT/DID YOU:

ATTEMPT	1st		2nd		3rd		
	GO	NO GO	GO	NO GO	GO	NO GO	INIT
1. Analyze the results of the tests?							
2. Tell the instructor what action must be taken?							
3. Was the action correct?							

REVISED PERFORMANCE TEST FOR 63D30 AND 63H30 STUDENTS

MOS 63 D30/63H30 (TRACKED VEHICLE MECHANIC)
AMTESS PERFORMANCE MEASURES

DIAGNOSIS OF GENERATING SYSTEM FOR MALFUNCTIONS
(VOLTAGE REGULATOR DEFECTIVE ON M1110 SERIES VEHICLE)

BACKGROUND DATA:

STUDENT NAME ____________________ SUBJECT # ____ MOS 63D30 ____ 63H30 ____

GRADE E-5 ___ E-6 ___ OTHER ___ CLASS _____ DATE ___/___/___

EXP. CONDITION: CONVENTIONAL _____ EXPERIMENTAL _____

LESSON INSTRUCTOR ____________________ TESTING INSTRUCTOR ____________________

PROCEDURE	GO	NO GO	INTERVENE
• I. CONFIRM MALFUNCTION INDICATED ON FORM 2404 TIME STARTED __________			
1. Select TM 9-2350-304-10.			
2. Set vehicle parking brake.			
3. Transmission lever in neutral and locked.			
4. Push throttle control in.			
5. Set master switch on.			
6. Set instrument switch on.			
7. Check master indicator light on.			
8. Push in start switch and hold until engine starts.			
9. Indicate generator warning light on.			
10. Check generator indicator gauge. (In the green = normal range)			
11. Pull out engine shutdown handle until engine stops.			
12. Set instrument switch off.			
13. Set master switch off.			
TIME FINISHED __________			
• II. TROUBLESHOOT ELECTRICAL SYSTEM TIME STARTED __________			
1. Select TM 9-2350-304-20.			
2. Select page 3-20 Troubleshoot index.			
3. Check generator cooling fan is operating.			

COMMENTS

PROCEDURE	GO	NO GO	INTERVENE	COMMENTS
4. Select page 3-81. Generator warning light is on while engine running or system fails generator regulator charging circuit test.				
5. Check generator ground lead 3 for bad connection.				
6. Check generator voltage regulator ground strap for bad connection.				
7. Check slave receptacle ground lead 50 for bad connection.				
TIME FINISHED ____________				
• III. PERFORM VTM HOOKUP AND CHECK-OUT TIME STARTED ____________				
1. Select TM 9-4910-571 12 and P.				
2. Select Table of Contents Section III 2-11.				
3. Select page 2-33 TK mode diagnostic procedures.				
4. Select page 2-81 CI engine diagnostic procedures index.				
5. Select page 2-82 601 VTM connections and checkout.				
6. Pull off the power switch on the VTM.				
7. Connect P1 of the power cable W6 to J1 on the VTM.				
8. Connect the red clip lead of cable W6 to the positive terminal of vehicle battery.				
9. Connect the black clip lead of cable W6 to the negative terminal of the vehicle battery.				
10. Push on the power switch on the VTM.				
11. Verify that display indicates .8.8.8.8 for 2 seconds and then changes to ----.				
12. Dial 66 into test select and press tes.				
13. Verify that VTM displays and holds "0066."				
14. Dial test select to 99 and press test.				
15. Verify that VTM displays "pass."				
16. Dial 60 into test select and press test.				
17. When "YEH" appears, dial "10" into test select.				
18. Press test switch and ensure VTM displays "10."				
TIME FINISHED ____________				

PROCEDURE	GO	NO GO	INTERVENE	COMMENTS
• V. TROUBLESHOOT GENERATOR CHARGING CIRCUIT.				
TIME STARTED ______				
1. Select page 3-82, page 3-83.				
2. Disconnect wiring harness from generator voltage regulator (portside to batteries).				
3. Attach Red clip lead to plug socket 6 (lead 5).				
4. Ground Black clip lead.				
5. Set master switch on.				
6. Read VTM.				
7. If VTM indicates approximately 24 volts, go to Step E.				
8. Set master switch off.				
9. Connect wiring harness to generator voltage regulator.				
10. Select page 3-86 Section E.				
11. Disconnect wiring harness from generator voltage regulator (starboard to generator).				
12. Connect Red clip lead to receptacle socket G (lead 2).				
13. Connect Black clip lead to ground				
14. Set Master switch on.				
15. Read VTM.				
16. If VTM indicates 3 or more volts, replace generator voltage regulator.				
17. Turn off Master switch.				
TIME FINISHED ______				
• VI. REMOVE/REPLACE GENERATOR VOLTAGE REGULATOR.				
TIME STARTED ______				
1. Select page 4-125.				
2. Turn off VTM.				
3. Disconnect both battery grounds.				
4. Disconnect both wiring harnesses from voltage regulator.				
5. Remove four screws and washers from brackets.				
6. Remove two screws, four washers and ground strap.				
7. Remove voltage regulator.				
8. Remove four screws and two brackets from voltage regulator.				
9. Installation of voltage regulator is reversal of removal procedure.				
TIME FINISHED ______				

PROCEDURE	GO	NO GO	INTERVENE	COMMENTS
• IV. PERFORM GENERATOR-REGULATOR CHARGING CIRCUIT TEST. TIME STARTED ______				
1. Select page 2-10 VTM operating test procedures index.				
2. Select page 2-13 test 89 0-45 volts DC.				
3. Attach P1 of test probe cable W2 to J4 on the VTM.				
4. Short the Red and Black clip leads of the cable together.				
5. Dial 89 into test select.				
6. Press and hold test in until the message CAL appears on the display.				
7. Release test.				
8. Verify that offset value is within limits of -6.8 to +6.8.				
9. Connect Red clip lead to the positive lead at the slave receptacle terminal.				
10. Connect Black clip lead to ground				
11. Start engine.				
12. Press test.				
13. Read VTM.				
14. Correctly interpret reading (should indicate approximately 27 volts if < 22 volts trouble-shoot battery).				
15. Set hand throttle to fast idle.				
16. Set vehicular light switch to service drive.				
17. Press headlight dimmer switch until High beam indicator light is on.				
18. Read VTM.				
19. Correctly interpret reading on VTM. (If voltage increases momentarily and then drops back to first reading, generator-regulator charging circuit is not operating properly.)				
20. Stop engine.				
21. Turn vehicular light switch off.				
TIME FINISHED ______				

PROCEDURE	GO	NO GO	INTERVENE	COMMENTS
** VII. PERFORM VTM HOOKUP AND CHECK-OUT TIME STARTED ______				
1. Select TM 9-4910-571 12 and P.				
2. Select page 2-33 TK mode diagnostic procedures.				
3. Select page 2-81 CI engine diagnostic procedures index.				
4. Select page 2-82 601 VTM connections and checkout.				
5. Pull off the power switch on the VTM.				
6. Connect P1 of the power cable W6 to J1 on the VTM.				
7. Connect the Red clip lead of cable W6 to the positive terminal of the vehicle battery.				
8. Connect the Black clip lead of cable W6 to the negative terminal of the vehicle battery.				
9. Push on the power switch on the VTM.				
10. Verify that display indicates .8.8.8.8 for 2 seconds and then changes to ----.				
11. Dial 66 into test select and press test.				
12. Verify that VTM displays and holds "0066."				
13. Dial test select to 99 and press test.				
14. Verify that VTM displays "pass."				
15. Dial 60 into test select and press test.				
16. When "YEH" appears, dial "10" into test select.				
17. Press test switch and ensure VTM displays "10."				
TIME FINISHED ______				
* VIII. PERFORM GENERATOR-REGULATOR CHARGING CIRCUIT TEST TIME STARTED ______				
1. Select page 2-10 VTM operating test procedures index.				
2. Select page 2-13 test 89 0-45 volts DC.				
3. Attach P1 of test probe cable W2 to J4 on the VTM.				

PROCEDURE	GO	NO GO	INTERVENE	COMMENTS
4. Short the Red and Black clip leads of the cable together.				
5. Dial 89 into test select.				
6. Press and hold test in until the message CAL appears on the display.				
7. Release test.				
8. Verify that offset value is within limits of -6.8 to +6.8.				
9. Connect Red clip lead to the positive lead at the slave receptacle terminal.				
10. Connect Black clip lead to ground.				
11. Start engine.				
12. Press test.				
13. Read VTM.				
14. Correctly interpret reading (should indicate approximately 27 volts if < 22 volts troubleshoot battery).				
15. Set hand throttle to fast idle.				
16. Set vehicular light switch to service drive.				
17. Press headlight dimmer switch until High beam indicator light is on				
18. Read VTM.				
19. Correctly read VTM. (If voltage increases momentarily and then drops back to first reading, generator-regulator charging circuit is not operating properly.)				
20. Stop engine.				
21. Turn vehicular light switch off.				
22. Correct interpretation of results. (Generator-regulator charging circuit is now functioning properly.)				
TIME FINISHED ______				

APPENDIX D

PERFORMANCE TESTS USED IN EXPERIMENT 5

SCHOOL ADMINISTERED PRACTICAL EXAM GRADE SHEET

UNITED STATES ARMY AIR DEFENSE SCHOOL
DIRECT SUPPORT MATERIEL DEPARTMENT
FIRING SECTION DIVISION
Fort Bliss, Texas 79916

PRACTICAL EXAMINATION GRADE SHEET

NAME/RANK ____________________ SSN ______________ DATE ____________

COURSE ________________ CLASS NO ____________ EXAM NO ____________

VERSION ________ DATE OF VERSION __________ FINAL SCORE ____________

*NOTE: The Primary Instructor will determine the make-up of the examination, i.e., Parts Location, Check Procedures or adjustments, and number of troubles. He will also determine the weight value for each portion of the examination. The examination will be approved by the Division Chief prior to being administered.

TIME START __________ FINISH __________ TIME ALLOTTED 5 Minutes

1. PARTS LOCATION AND FUNCTION

Total points to be scored 20. Points deducted for each incorrect 2. Maximum cuts 10.

NAME OF PART	LOCATED		FUNCTION	
a. ____________________	Yes	No	Yes	No
b. ____________________	Yes	No	Yes	No
c. ____________________	Yes	No	Yes	No
d. ____________________	Yes	No	Yes	No
e. ____________________	Yes	No	Yes	No

TIME START __________ FINISH ____________ TIME ALLOTTED 40 Minutes

2. CHECK PROCEDURES AND/OR ADJUSTMENTS

Total points to be scored 9. Points deducted for each incorrect 3. Maximum cuts 3.

TABLE	STEP	WEIGHT
a.		
b.		
c.		

3. SYMPTOM RECOGNITION

Total points to be scored __20__.

a. ______________________________ Correct Symptom

b. ______________________________ Student's Symptom

4. SIGNAL TRACING

Total points to be scored __51__ points.

a. Channel	20	Yes	No
b. Chassis	25	Yes	No
c. Corrective Action	6	Yes	No

5. ADDITIONAL POINT CUTS TO BE DEDUCTED FROM FINAL GRADE.

A. EQUIPMENT VIOLATIONS

A deduction of __5__ points will be made for each violation. This will include external test equipment. Maximum cuts __4__.

a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

B. PERSONNEL SAFETY VIOLATION

A deduction of __10__ points will be made for any personnel safety violation committed. Instructor must explain violation to student and make entry in remarks section. Maximum cut __1__.

REMARKS: ______________________________

FIRST WRITTEN TEST

UNITED STATES ARMY AIR DEFENSE SCHOOL
DIRECTORATE OF TRAINING DEVELOPMENTS
HAWK DIVISION
Fort Bliss, Texas 79916

File No. DM2.95802
JANUARY 1982

Examination Version 1A

TIME REQUIRED:

5 min for Orientation
80 min for Examination
15 min for Critique

DIRECTIONS:

This examination consists of 25 questions on 7 pages. All questions are equally weighted. MAKE NO MARKS IN THIS BOOKLET unless specifically directed to do so by the instructor. Using a No. 2 pencil, record all answers on your student answer form by drawing a heavy mark through the letter within the space reflecting the selected answer (see example below). DO NOT mark outside the space. No pens or colored pencils are allowed. Select only the best answer from the four choices given for each question. Make thorough erasures when necessary. Record necessary information relative to examination version on your answer form. This is an open book examination.

EXAMPLE:

1. One gallon is equal to: 1. A B C D

   a. 2 quarts
   b. 3 pints
   c. 4 quarts
   d. 6 quarts

Student material needed for examination

1. Student answer form
2. No. 2 Pencil
3. Student Critique, USAADCEN: FORM 128.

WRITTEN EXAMINATION

TRANSMITTER (HIPIR)

1. The Modulation Circuits produces how many signals? (Fig 24-15)

   a. 3

   b. 5

   c. 7

   d. None of the above.

2. What is the purpose of Phase Modulator A-12? (Fig 24-17, Zone B-10)

   a. Adds Coding to Range Modulated Carrier.

   b. Adds Phase Modulator Bias to the Range Modulated Carrier.

   c. Removes the Range Modulated Carrier signal.

   d. Removes Coding from the Range Modulated Carrier.

3. What signal provides correct Master oscillator isolation? (Fig 24-17, Zone B-1)

   a. Isomodulator Bias signal

   b. High Frequency Noise degeneration signal

   c. Low Frequency Noise degeneration and Range modulation

   d. All of the above

4. Why is wavemeter test set connected to wavemeter test jack J1? (Fig 24-17, Zone B-3)

   a. Measure reflected R.F. Power.

   b. Measure the power level of the R.F. Carrier.

   c. Check and adjust High Frequency Noise degeneration.

   d. Check and adjust the M.O. Frequency.

5. Reflected R.F. Power monitor signal is applied to meter________ and should read in the ________ area in a normal condition. (Fig 25-22, Zone B-1)

a. M-5, Blue

b. M-7, Blue

c. M-1, Green

d. M-1, Red

6. Where is the ranging modulation impressed on the R.F. Carrier? (Fig 24-17)

a. Master oscillator (B1)

b. Isomodulator (B-2)

c. Power Amplifier (B-7)

d. Phase Modulator (B-10)

7. The Frequency of the Master oscillator V1 is set by ________. (TM 9-1430-533-12-1, Table 3-16, step 12; TM 9-1430-533-12-2-2)

a. Frequency Command Test S-3 (Fig 25-21, D-15)

b. Assigned Frequency Switch S-3 (Fib 25-21, A-15)

c. Master oscillator voltage adjust R1 (Fig 24-11, B-5)

d. Adjusting Master oscillator tuning control (TM 9-1430-533-12-1; Fig 3-19, Item 31)

8. To apply TC enable modulation to the Coding signal, the following Missile Message must be present. (Fig 24-16, Zone B-14)

a. A and B, but not C.

b. A and C, but not B.

c. B and C, but not A.

d. A, B and C.

9. The Forward R.F. power meter M-5 (fig 25-22, Zone B-3) reads in the green area for P.A., but does not deflect in the M.O. position. A possible cause of the trouble is ______________________.

a. V1 filaments is open. (Fig 24-17, Zone B-1)

b. CR1 is defective. (Fig 24-17, Zone D-8)

c. CR1 is defective. (Fig 25-22, Zone A-1)

d. FL1 is open. (Fig 25-22, Zone B-2)

10. The 310 KHz coding signal frequency modulates the R.F. Carrier in the ______________. (Fig 24-17)

a. Isomodulator (Zone B-2)

b. Phase modulator (Zone B-10)

c. Microwave switch (Zone B-4)

d. Range and Coding Amplifier Oscillator (Fig 24-16, Zone A-15)

11. What is the purpose of the Detected Range Deviation Signal? (Fig 24-16, Zone A-6)

a. Used to disable Ranging.

b. Enables ranging oscillator.

c. Used to Frequency Modulate the R.F. Carrier.

d. Controls the amount of Ranging impressed on the R.F. Carrier.

12. Where does Low Frequency Noise Cancellation occur? (TM 9-1430-533-12-2-2, Fig 24-17)

a. Bridge nulling amplifier (Fig 24-19, Zone A-14)

b. High and Low Frequency Amplifier. (Fig 24-19, Zone A-16)

c. Master oscillator V1 (Fig 24-17, Zone B-1)

d. Phase Modulator A-12 (Fig 24-17, Zone B-10)

13. When coding is removed, the missile in flight will __________.
(Fig 24-16, Zone A-16)

a. Home on Jamming

b. Self Destruct

c. Condition itself for high altitude flight.

d. None of the above

14. The output of the Transmitting System is a high-power frequency modulated (F.M.) Microwave Carrier which normally contains ________ and ________ modulations. (Fig 24-15, 24-17)

a. Time Constant, Home on Jam

b. T.C. Enable, Ranging

c. Coding, Home on Jam

d. Coding, Ranging

15. With the transmitter test set selector switch in Pos 2 (XTAL Balance), the function Monitor meter is adjusted for "Green Area" with __________.
(TM 9-1430-533-12-1, Table 3-16, step 2h)

a. High Power load AT3. (Fig 24-17, Zone C9)

b. Isolation Mod Bias Adj R-45. (Fig 24-20, Zone C8)

c. 14DB Variable Attenuator. (Fig 24-17, Zone B-7)

d. Code Bias Adj R-43. (Fig 24-30, Zone D8)

16. The Power Amplifier and Master Oscillator filament are adjusted while the HIPIR is in the ________ condition. (TM 9-1430-533-12-1, Table 3-11, step 4 and 5)

a. Standby

b. False Radiate

c. Full Radiate

d. OFF

17. What resistors make up the voltage divider network that remove coding from the R.F. Carrier? (Fig 24-16, Zone A, B-16)

a. R-53 and R-54 to Ground.

b. R-52, R-53 and R-54 to Ground.

c. R-52 and R-53 to Ground.

d. R-52 and R-54 to Ground.

18. During the transmitter weekly checks, ____________ is adjusted for the proper amplitude of the Coding signal. (TM 9-1430-533-12-1, Table 3-16; TM 9-1430-533-12-2-2)

a. R-7 HOJ % MOD (Fig 24-15, B-15)

b. R-40 TC % MOD (Fig 24-16 B-16)

c. R-59 Coding Drive (Fig 24-16, C-17)

d. R-43 Code Bias Adj (Fig 24-20, D-8)

19. What is the Frequency Output of V1 Range Oscillator? (Fig 24-16, Zone A-10)

a. 30 Hz

b. 310 Hz

c. 30 KHz

d. 310 KHz

20. What is the purpose of Relay K4 (Interlock Control)? (Fig 24-20, Zone A-5)

a. Remove microwave switch bias during Arcing.

b. Prevent radar from going to radiate until troubles are found.

c. Prevent local oscillator search during Arcing.

d. Initiate local oscillator search during Arcing.

21. When ION Probe test switch is placed to position 2, the "Radiate Intlk Open IND " lamp DS1 will _____________.
(TM 9-1430-533-12-1, Table 3-16, step 1; TM 9-1430-533-12-2-2, Fig 24-17, Zone A10; Fig 24-20, Zone B8)

a. Extinguish

b. Illuminate

c. Not be affected.

c. None of the above.

22. Microwave switch bias is applied to the Microwave switches when _____________.(Fig 24-17 Zone C4)

a. S-7 is closed (Fig 24-20 Zone C1)

b. High or low power arcing occurs in the waveguide.

c. No arcing occurs in the waveguide.

d. Radiate Cutoff Relay K-3 in energized. (Fig 24-20 Zone C7)

23. Performing table 3-16, step 7d of TM 9-1430-533-12-1, is out of tolerance but step 7c is good. A possible cause of this trouble is _____________.
(TM 9-1430-533-12-2-2)

a. Pin 13 of Remote Relay K-1 open. (Fig 24-16 Zone C4)

b. Slip Ring SR 58 open. (Fig 24-16 Zone C1)

c. J1 Pin P open. (Fig 24-16 Zone D12)

d. Pin 5 of V4 Modulation Control Open (Fig 24-16 Zone B10)

24. The HOJ Modulation uses _________ as a Carrier.
(TM 9-1430-533-12-2-2, Fig 24-15 and Fig 14-16)

a. 30 Hz AM

b. 30 Hz FM

c. 310 KHz

d. 455 Hz

25. The HIPIR has an assigned Master Oscillator frequency of 11. The Master Oscillator tuning control should be set to ______________.
(TM 9-1430-533-12-1, Table 3-16, step 10; TM 9-1430-533-12-1, Fig 3-21)

a. 30

b. 50

c. 70

d. 90

SECOND WRITTEN TEST

5

UNITED STATES ARMY AIR DEFENSE SCHOOL
DIRECTORATE OF TRAINING DEVELOPMENTS
HAWK DIVISION
Fort Bliss, Texas 79916

597602

File No. DM2.[redacted]
JANUARY 1982

Examination Version A

TIME REQUIRED:

5 min for Orientation
80 min for Examination
15 min for Critique

DIRECTIONS:

This examination consists of 25 questions on 7 pages. All questions are equally weighted. MAKE NO MARKS IN THIS BOOKLET unless specifically directed to do so by the instructor. Using a No. 2 pencil, record all answers on your student answer form by drawing a heavy mark through the letter within the space reflecting the selected answer (see example below). DO NOT mark outside the space. No pens or colored pencils are allowed. Select only the best answer from the four choices given for each question. Make thorough erasures when necessary. Record necessary information relative to examination version on your answer form. This is an open examination.

EXAMPLE:

1. One gallon is equal to: 1. A B C D

   a. 2 quarts
   b. 3 pints
   c. 4 quarts
   d. 6 quarts

Student material needed for examination

1. Student answer form
2. No. 2 Pencil
3. Student Critique, USAADCEN: FORM 128.

WRITTEN EXAMINATION DMS 97600

TRANSMITTER (HIPIR)

1. During adjustment of Repeller Voltage adjust R-16 (Fig 24-18, B-16), which meter is adjusted for a peak indication?
(TM 9-1430-533-12-1, Table 3-16, step 3; TM 9-1430-533-12-2-2)

a. Function Monitor Meter (M1) in POS 4. (Fig 25-23, D-5)

b. Degeneration Function Monitor Meter (M3) in position 3A LO POWER. (Fig 25-23, A-5)

c. Degeneration Function Monitor Meter (M3) in position 4A DISC. (Fig 25-23, A-5)

d. Receiver Function Monitor Meter (M1) in position 4, LO POWER. (Fig 25-29, B-6)

2. Cavity Servo Motor B1 will not rotate, a possible cause of this could be ______________. (Fig 24-19, A-30)

a. Cavity AFC Lock Relay K3-Pin 1 is open. (Fig 24-19, B-27)

b. Contact 4 of S1 Cavity unlock shorted to ground. (Fig 24-19, C-26)

c. Contact 2A of S5 open. (Fig 25-24, A-3)

d. Contact 6 of AFC Lock Relay K1 is open. (Fig 24-18 B-17)

3. With the Cavity tuned to the Carrier Frequency, the output of crystal detector CR1 is __________. (Fig 24-19, B-5)

a. an A.C. Voltage

b. a varying D.C. Voltage.

c. a negative D.C. Voltage.

d. a positive D.C. Voltage.

4. When Sweep thyraton V2 (Fig 24-18, B15) is enable, it will generate a free running __________ saw tooth sweep. (Fig 24-18)

a. 10 Hz

b. 5 KHz

c. 20 Hz

d. 5 Hz

5. The TUNE UP, TUNE DOWN Relays will both be deenergized when ______________. (Fig 24-18, C17)

   a. AFC Lock Control V7 cut off and AFC Lock Relay K1 Deenergized. (C & D-14)

   b. AFC Lock Control V7 conducts and AFC Lock Relay K1 Energized.

   c. Local oscillator is in the search mode.

   d. None of the above.

6. The output of AFC Reference Level Detector CR6 is maximum negative when ______________. (Fig 24-18, C-10)

   a. at 31 MHz

   b. below 31 MHz

   c. above 31 MHz

   d. None of the above.

7. When adjusting cross coupling adj R-59, what noise is being adjusted and the maximum reading in ________ and __________? (Fig 24-18, B-1) (TM 9-1430-533-12-1, Table 3-16, step 6)

   a. F.M. and 4 micro amp (ua).

   b. A.M. and 8 micro amp (ua).

   c. A.M. and 4 micro amp (ua).

   d. F.M. and 8 micro amp (ua).

8. The useable Frequency at the output of the Reference Balance Mixer is ______________. (Fig 24-18, B-5)

   a. Difference Frequency

   b. Transmitted Frequency

   c. Local Oscillator Frequency

   d. None of the above.

9. In order to disable Sweep Thyratron V2 ____________. (Fig 24-18, B-16)

   a. AFC Lock Relay K1 Deenergized. (C-14)

   b. AFC Lock Relay K1 has no effect. (C-14)

   c. AFC Lock Relay K1 Energized. (C-14)

   d. AFC Lock Control V7 Cut Off. (D-14)

10. The Local Oscillator operates in __________ modes. (Fig 24-15, Fig 24-18)

   a. 1

   b. 3

   c. 2

   d. 4

11. The Reference level monitor is monitored on ________ Meter M _______. (Fig 14-18, C-11)

   a. Volt, 1. (Fig 25-23)

   b. Amp, 1. (Fig 25-23)

   c. Amp, 3. (Fig 25-23)

   d. Volt, 3. (Fig 25-23)

12. It takes about ____________ to change the Klystron Cavity from one extreme to the other. (Fig 24-18, B-21)

   a. 30 seconds

   b. 60 seconds

   c. 90 seconds

   d. None of above.

13. When adjusting Variable Attenuator Z1, it is adjusting what signals? (TM 9-1430-533-12-1, Table 3-16, step 3; TM 9-1430-533-12-2-2, Fig 24-18)

a. Ref Level

b. Discriminator

c. Cavity XTAL

d. L.O. Power

14. The Front IF (C7) and Reference IF (D-8) is applied to the FM Discriminator (B-9), in what phase relationship? (EM 9-1430-533-12-2-2, Fig 24-19)

a. 90° in phase.

b. 180° in phase.

c. 90° out of phase.

d. 180° out of phase.

15. When adjusting Ph Null R-6 (Fig 24-19, C-13.5) and Ampl Null R-46 (Fig 24-19, D-13.5), the indication on Degeneration Function monitor Meter M-3 (Fig 25-24, A-3), with selector switch in Bridge Null position should read in the __________ area. (TM 9-1430-533-12-1, Table 3-16, step 6; TM 9-1430-533-12-2-2, Fig 24-19)

a. Blue

b. Orange

c. Green

d. Yellow

16. The output of A-3 AF-RF Amplifier (Fig 24-19, Zone B-23.5) is applied to A-1 Isomodulator (Fig 24-17, Zone B-1) for ________. (TM 9-1430-533-12-2-2).

a. Low Frequency Noise Cancellation generated by the Master Oscillator. (Fig 24-17, B-1)

b. Low and High Frequency Noise Cancellation generated by the Power Amplifier. (Fig 24-17, B-7)

c. High Frequency Noise Cancellation generated by the Master Oscillator. (Fig 24-17, B-1)

d. None of the above.

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17. The Cavity Tuning Motor Control Voltage is controlled by __________. (Fig 24-19, Zone B-29)

a. Switch S-1 (Fig 24-19, Zone A-29)

b. Coarse Frequency Adjust (Zone B-29)

c. AFC Lock Relay K1. (Fig 24-18, C-14)

d. None of the above.

18. Low Frequency Noise Degeneration and Range Modulation is applied to the Master Oscillator to ____________ and ____________ the carrier. (Fig 24-17, B-1)

a. Cancel internally generated M.O. low frequency noise, frequency modulate.

b. Cancel internally generated M.O. low frequency noise, amplitude modulate.

c. Isolate the M.O. from the P.A., frequency modulate.

d. All of the above.

19. Cavity Servo Zero adj R-29 is adjusted for a peak in the _________ area,(Fig 24-19, C-27) on the Degeneration Function Monitor Meter. (TM 9-1430-533-12-1, Table 3-16, step 6)

a. Blue

b. Yellow

c. Green

d. Orange

20. Purpose of Interlock Control Relay K4 is to ________. (Fig 24-20, Zone A-5).

a. Prevent Local Oscillator Search during R.F. Carrier interruption.

b. Allow the local oscillator to tune during ARCing.

c. Cause the radar to go to a Standby condition.

d. None of the above.

21. Purpose of the Frequency Counter is to __________. (Fig 24-20, Zone C-6)

a. Cause the radar to go to an Off condition.

b. Not affect the radar in a Radiate condition.

c. Place the radar in Standby during repetitive Arcing.

d. None of the above.

22. Microwave Switch Bias is applied to A-5 and A-15 Ferrite switches when __________. (Fig 24-20, Zone B-10 and Fig 24-17, Zone C-4)

a. Arcing occurs at the output of the P.A.

b. Arcing occurs at the output of the M.O.

c. Arcing occurs in the Waveguide between the P.A. and the Transmitting Antenna.

d. No Arcing occurs in the Waveguide between the P.A. and Transmitting Antenna.

23. When Discriminator High controls the output of the Klystron Local Oscillator, it is in what mode of operation?

a. Search

b. A.F.C.

c. Search and A.F.C.

d. Manual

24. The HIPIR has __________ radiating element (Antenna). (TM 9-1430-533-12-2-2, Fig 24-15 and Fig 24-17)

a. 1

b. 2

c. 3

d. 4

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25. Where is the Transmitter Frequency Command monitored during HIPIR Daily checks? (TM 9-1430-533-12-1, Table 3-5, step 4; TM 9-1430-533-12-2-2 Fig 24-16, Zone C-26; Fig 25-21, Zone D-14)

a. Transmitter panel #2.

b. Fuse and panel.

c. Output Test Indicator A3DS5.

d. None of the above.

WEEKLY CHECK PROCEDURE

MOS 24 C (HAWK MISSILE SECTION FIRING MECHANIC) PERFORMANCE MEASURES

I. BACKGROUND DATA

STUDENT NAME________________________ S.S. #________________

ROSTER #____________________________ CLASS________________

EXP. CONDITION______________________ INSTRUCTOR________________

DATE________________________________ TIME STARTED________________

ATTEMPT #___________________________ GRADE: PASS______ FAIL______

II. ADJUSTMENTS

*INDICATES ADJUSTMENT IS REQUIRED.

PROCEDURE	GO	NO GO	COMMENTS
TIME STARTED ________			
1. CHECK ION TEST.			
Verify that BATTLE SHORT switch is set to NORMAL. (Light Off)	__	__	
a. Perform the following interlock bypass procedure:			
(1) INTERLOCK OVERRIDE pushbutton (22, fig. 2-5)...press and hold.	__	__	
(2) Transmitter panel 3 (3, fig. 1-2)...open.	__	__	
(3) Press, turn, and lock the interlock switch behind transmitter panel 3.	__	__	
(4) Interlock...release and observe that the interlock switch remains locked.	__	__	
(5) INTERLOCK OVERRIDE pushbutton... release.	__	__	
b. ION PROBE TEST switch (6, fig. 3-19) ...POS 2, then release switch.	__	__	
Radar goes into standby condition.	__	__	
c. RADIATE pushbutton...press and release.	__	__	
Radar remains in standby condition.	__	__	

PROCEDURE	GO	NO GO	COMMENTS
d. RADIATE INTLK RESET pushbutton (4, fig. 3-19)...press and release.	___	___	
RADIATE INTLK OPEN IND lamp... extinguishes.	___	___	
e. RADIATE pushbutton...press and release.	___	___	
RADIATE lamp...illuminates.	___	___	
f. Transmitter panel 3...close and secure.	___	___	
TIME FINISHED ________			
TIME STARTED ________			
2. CHECK MASTER OSCILLATOR AND POWER AMPLIFIER			
a. STANDBY pushbutton...press and release.	___	___	
b. Master oscillator BEAM circuit breaker...ON.	___	___	
c. Power amplifier BEAM circuit breaker...ON.	___	___	
d. REGULATOR VOLTS switch...MO.	___	___	
*Master oscillator FILAMENT AMPERES meter...within 0.1 amps of value on decal located beneath the meter.	___	___	
*Adjust master oscillator filament control.	___	___	
Power amplifier FILAMENT VOLTAGE meter...red line.	___	___	
e. RADIATE pushbutton...press and release.	___	___	
REGULATOR VOLTS meter...1.4 to 1.6 KV. (or 1.1 to 1.3)	___	___	
Master oscillator BEAM VOLTAGE meter...green area.	___	___	
Master oscillator BEAM AMPERES meter...50 to 100.	___	___	
f. REGULATOR VOLTS switch...PA.	___	___	
*REGULATOR VOLTS meter...0.9 to 1.0 KV.	___	___	
*Adjust power amplifier beam voltage control.	___	___	
Power amplifier BEAM VOLTAGE meter... green area.	___	___	
Power amplifier BEAM AMPERES meter... 0.75 to 1.25.	___	___	

PROCEDURE	GO	NO GO	COMMENTS
g. REGULATOR VOLTS switch...OFF.	___	___	
h. Transmitter test set SELECTOR switch (11, fig. 2-8)...position 2 (XTAL BALANCE).	___	___	
FUNCTION MONITOR meter (1, fig. 2-8)...green area.	___	___	
i. Forward rf power switch...PA.	___	___	
FORWARD RF POWER meter (3, fig. 2-7)...green area.	___	___	
j. ARC DETECTOR TEST pushbutton (10, fig. 2-7)...press and hold.	___	___	
FORWARD RF POWER meter...blue area.	___	___	
FUNCTION MONITOR meter...decreases.	___	___	
k. ARC DETECTOR TEST pushbutton... release.	___	___	
FORWARD RF POWER meter...green area.	___	___	
FUNCTION MONITOR meter...green area.	___	___	
l. REFLECTED RF POWER meter (2, fig. 2-7)...observe.	___	___	
REFLECTED RF POWER meter...green area.	___	___	
TIME FINISHED ________			
TIME STARTED ________			
3. CHECK LOCAL OSCILLATOR CRYSTAL CURRENT.			
Degeneration function SELECTOR switch (8, fig. 2-7)...LO POWER.	___	___	
*Degeneration function MONITOR meter (4, fig. 2-7)...indication remains stable in the upper orange area within two minutes.	___	___	
*Carefully adjust REPELLER V ADJ control (16, fig. 2-9) for a peak.	___	___	
*Adjust local oscillator attenuator (9, fig. 3-19) for upper orange area.	___	___	
Degeneration function monitor meter... upper orange area.	___	___	
TIME FINISHED ________			
TIME STARTED ________			

PROCEDURE	GO	NO GO	COMMENTS
4. CHECK REFERENCE LEVEL.			
Degeneration function SELECTOR switch... REF LEVEL.	___	___	
Degeneration function MONITOR meter... indication remains stable in the orange or green area.	___	___	
TIME FINISHED ________			
TIME STARTED ________			
5. CHECK ISOMODULATOR BIAS.			
a. Transmitter test set SELECTOR switch...position 5 (ISO MOD BIAS).	___	___	
*b. ISOLATION MOD BIAS ADJ control (1, fig. 3-19)...adjust until	___	___	
*FUNCTION MONITOR meter...nulls in blue area.	___	___	
TIME FINISHED ________			
TIME STARTED ________			
6. CHECK NULLING FUNCTION.			
a. Coding switch (25, fig. 2-1)... CODING OFF. (Down)	___	___	
b. Ranging switch (24, fig. 2-1)... RANGING OFF. (Down)	___	___	
c. Transmitter test set SELECTOR switch...position 9 (PHASE CONTROLLER VOLTAGE).	___	___	
d. Degeneration function SELECTOR switch (8, fig. 2-7)...CAVITY XTAL.	___	___	
Transmitter test set FUNCTION MONITOR meter...green area.	___	___	
Degeneration function MONITOR meters (4, fig. 2-7)...orange or green area.			

PROCEDURE	GO	NO GO	COMMENTS
e. Degeneration function SELECTOR switch...BRIDGE NULL.	___	___	
Degeneration function MONITOR meter...blue area.	___	___	
f. Transmitter test set SELECTOR switch...position 12 OSC OUT (LO FREQ LOOP GAIN).	___	___	
g. HF DISABLE and LF DISABLE push-buttons...press and hold.	___	___	
*h. LEVEL ADJ control (7, fig. 2-8)... adjust until	___	___	
*TRANSMITTER NOISE meter...50 μa.	___	___	
i. Transmitter noise switch (11, fig. 2-7)...AM and hold.	___	___	
*TRANSMITTER NOISE meter...4 μa maximum.	___	___	
*Adjust CROSS COUPLING ADJ variable resistor (8, fig. 2-9) for null.	___	___	
j. Transmitter noise switch...release.	___	___	
k. TRANSMITTER NOISE meter...50 μa. If not, adjust LEVEL ADJ control for 50 μa.	___	___	
l. LF DISABLE pushbutton...release.	___	___	
TRANSMITTER NOISE meter...less than 25μa.	___	___	
Degeneration function MONITOR METER...blue area.	___	___	
m. HF DISABLE pushbutton...release.	___	___	
TRANSMITTER NOISE meter...decreases 6 μa maximum.	___	___	
n. Degeneration function SELECTOR switch...OFF.	___	___	

TIME FINISHED ________

PROCEDURE	GO	NO GO	COMMENTS
TIME STARTED ________			
7. CHECK RANGE DEVIATION.			
a. Ranging switch (24, fig. 2-1)... RANGING ON.	___	___	
b. Receiver functions selector switch (17, fig. 2-1). REF LEVEL.	___	___	
RECEIVER FUNCTIONS meter (15, fig. 2-1)...orange or green area.	___	___	
c. Transmitter test set SELECTOR switch...position 15 (RANGE REF).	___	___	
FUNCTION MONITOR meter...15 to 35 μa.	___	___	
d. Transmitter test set SELECTOR switch...position 17 (RANGE DEVIATION.	___	___	
FUNCTION MONITOR meter...green area.	___	___	
Transmitter test set SELECTOR switch...position 16 (DEV CAL).	___	___	
NORMAL/CAL switch (13, fig. 2-8)... CAL and hold.	___	___	
*RANGE CAL control (6, fig. 2-8)... adjust until	___	___	
*FUNCTION MONITOR meter...25 μa.	___	___	
NORMAL/CAL switch...release.	___	___	
Transmitter test set SELECTOR switch...position 17 (RANGE DEVIATION).	___	___	
*RANGE DEV control (14, fig. 2-9)... adjust until	___	___	
*FUNCTION MONITOR meter...25 μa.	___	___	
TIME FINISHED ________			
TIME STARTED ________			
8. CHECK CODING DEVIATION.			
a. Coding switch...CODING ON.	___	___	
b. Transmitter test set SELECTOR SWITCH...position 19 (CODING DEVIATION).	___	___	
FUNCTION MONITOR meter...15 to 20 μa.	___	___	
TIME FINISHED ________			

PROCEDURE	GO	NO GO	COMMENTS
TIME STARTED ________			
9. CHECK % MODULATION.			
a. Transmitter test set SELECTOR switch...position 20 (% MODULATION).	___	___	
b. TOJ switch (26, fig. 2-1)... DISABLE.	___	___	
c. % MOD CODING control...adjust until the FUNCTION MONITOR meter indicates zero.	___	___	
d. HOJ TEST pushbutton (11, fig. 2-9)... press and hold.	___	___	
*FUNCTION MONITOR meter...24 to 26 μa.	___	___	
*Adjust HOJ % MOD control (9, fig. 2-9) for a 25-μa.	___	___	
e. HOJ TEST pushbutton...release.	___	___	
FUNCTION MONITOR meter...less than 2 μa.	___	___	
f. TC TEST pushbutton (19, fig. 2-9)... press and hold.	___	___	
FUNCTION MONITOR meter...24 to 26 μa.	___	___	
g. HOJ TEST and TC pushbuttons...press and hold.	___	___	
FUNCTION MONITOR meter...38 μa min.	___	___	
h. HOJ TEST and TC TEST pushbuttons... release.	___	___	
i. Coding switch...COOING OFF.	___	___	
j. Transmitter test set SELECTOR switch...position 1 (OFF).	___	___	
TIME FINISHEO ________			
TIME STARTED ________			
10. CHECK TRANSMITTER FREQUENCY COMMANO.			
a. FREQUENCY COMMANO TEST pushbutton (24, fig. 2-6)...press and hold.	___	___	
b. Output test indicator switch (9, fig. 2-3)...positions 1 through 4.	___	___	
OUTPUT TEST INOICATOR lamp (8, fig. 2-3)...illuminates in positions 1 through 4.	___	___	

PROCEDURE	GO	NO GO	COMMENTS
c. FREQUENCY COMMAND TEST pushbutton... release.			
*d. MASTER OSC ASSIGNED FREQUENCY switch (12, fig. 2-6)...to the assigned setting (8).			
e. Output test indicator switch... positions 1 through 4.			
Output test indicator lamp illuminates and/or extinguishes accordingly (off, off, off, on)			
f. Output test indicator switch...OFF.			
TIME FINISHED ________			

REVISED PERFORMANCE TEST

FOR PROBLEMS 19 AND 20

(LAST GOOD/FIRST BAD METHOD)

III. TROUBLESHOOTING - #19

TROUBLE: BAD REFERENCE BALANCE MIXER CRYSTALS.

SOLUTION: REPLACE CRYSTALS.

X DENOTES BAD INDICATION

PASS/FAIL

LIKELY ERRORS: 1. Replace IF amplifier.

PROCEDURE	GO	NO GO	COMMENTS/ERRORS
TIME STARTED ________			
SELECT TM 9-1430-533-12-1			
SELECT PG. 3-39			
3. CHECK LOCAL OSCILLATOR CRYSTAL CURRENT.			
Degeneration function SELECTOR switch (8, fig. 2-7)...LO POWER.	—	—	
X Degeneration function MONITOR meter (4, fig. 2-7)...indication remains stable in the upper orange area within two minutes.	—	—	
TIME FINISHED ________			
TIME STARTED ________			
4. CHECK REFERENCE LEVEL.			
Degeneration function SELECTOR switch... REF LEVEL.	—	—	
X Degeneration function MONITOR meter... indication remains stable in the orange or green area.	—	—	
TIME FINISHED ________			
PERFORM FOLLOWING TESTS OR BRANCH AND FLOW.			
CENTRAL TESTS:			
TIME STARTED ________			
1. Open panel #3 and look at shaft.	—	—	
TIME FINISHED ________			

LIKELY ERRORS: 1. Replace IF amplifier

PROCEDURE	GO	NO GO	COMMENTS/ERRORS
TIME STARTED ________			
2. Check degeneration function monitor for "no kick."	__	__	
TIME FINISHED ________			
TIME STARTED ________			
3. Select TM 9-1430-533-12-2	__	__	
Select pg. 2404 and 2405.	__	__	
TIME FINISHED ________			
4. TIME STARTED ________			
Use IF TEST SET for reference level test.	__	__	
TIME FINISHED ________			
TIME STARTED ________			
5. Perform resistance check on crystals.	__	__	
TIME FINISHED ________			

RELATED TESTS	YES	NO
TIME STARTED ________		
1. Troubleshoot local oscillator.	__	__
TIME FINISHED ________		
LIKELY ERRORS:		
TIME STARTED ________		
1. Replace IF amplifier.	__	__
TIME FINISHED ________		

OTHER ERRORS:

TIME STARTED	TIME FINISHED	DESCRIPTION

FAULT ISOLATION PROCEDURES:

TIME STARTED ____________

TIME FINISHED ___________

DESCRIPTION: ____

____

STUDENT CORRECTLY IDENTIFIES TROUBLE?

PASS/FAIL

LIKELY ERRORS: 1. Replace hi/low frequency amplifier after position #13 check.
2. Replace IF amplifier after position #13 check.

III. TROUBLESHOOTING - #20

TROUBLE: W2P1 OPEN ON AF-RF AMPLIFIER

SOLUTION: REPAIR OPEN BETWEEN AF-RF AMPLIFIER AND ISO MODULATOR.

X DENOTES BAD INDICATION

PROCEDURE	GO	NO GO	COMMENTS/ERRORS
TIME STARTED ________			
SELECT TM 9-1430-533-12-1			
SELECT PG. 3-39			
3. CHECK LOCAL OSCILLATOR CRYSTAL CURRENT.			
Degeneration function SELECTOR switch (8, fig. 2-7)...LO POWER.	___	___	
Degeneration function MONITOR meter (4, fig. 2-7)...indication remains stable in the upper orange area within two minutes.	___	___	
TIME FINISHED ________			
TIME STARTED ________			
4. CHECK REFERENCE LEVEL.			
Degeneration function SELECTOR switch... REF LEVEL.	___	___	
Degeneration function MONITOR meter... indication remains stable in the orange or green area.	___	___	
TIME FINISHED ________			
TIME STARTED ________			
5. CHECK ISOMODULATOR BIAS.			
a. Transmitter test set SELECTOR switch...position 5 (ISO MOD BIAS).	___	___	
b. ISOLATION MOD BIAS ADJ control (1, fig. 3-19)...adjust until	___	___	
FUNCTION MONITOR meter...nulls in blue area.	___	___	
TIME FINISHED ________			

LIKELY ERRORS: 1. Replace [illegible] low frequency amplifier after position #13 check
2. Replace IF amplifier afte position #13 check.

PROCEDURE	GO	NO GO	COMMENTS/ERRORS
TIME STARTED ________			
6. CHECK NULLING FUNCTION.			
a. Coding switch (25, fig. 2-1)... CODING OFF.	___	___	
b. Ranging switch (24, fig. 2-1)... RANGING OFF.	___	___	
c. Transmitter test set SELECTOR switch...position 9 (PHASE CONTROLLER VOLTAGE).	___	___	
d. Degeneration function SELECTOR switch (8, fig. 2-7)...CAVITY XTAL.	___	___	
Transmitter test set FUNCTION MONITOR meter...green area.	___	___	
Degeneration function MONITOR meters (4, fig. 2-7)...orange or green area.	___	___	
e. Degeneration function SELECTOR switch...BRIDGE NULL.	___	___	
Degeneration function MONITOR meter...blue area.	___	___	
f. Transmitter test set SELECTOR switch...position 12 OSC OUT (LO FREQ LOOP GAIN).	___	___	
g. HF DISABLE and LF DISABLE push-buttons...press and hold.	___	___	
h. LEVEL ADJ control (7, fig. 2-8)... adjust until	___	___	
TRANSMITTER NOISE meter...50 μa.	___	___	
i. Transmitter noise switch (11, fig. 2-7)...AM and hold.	___	___	
TRANSMITTER NOISE meter...4 μa maximum.	___	___	
j. Transmitter noise switch...release.	___	___	

LIKELY ERRORS: 1. Replace hi/low frequency amplifier after position #13 check.
2. Replace IF amplifier after position #13 check.

PROCEDURE	GO	NO GO	COMMENTS
k. TRANSMITTER NOISE meter...50 μa. If not, adjust LEVEL ADJ control for 50 μa.	___	___	
l. LF DISABLE pushbutton...release.	___	___	
TRANSMITTER NOISE meter...less than 25μa.	___	___	
Degeneration function MONITOR METER...blue area.	___	___	
m. HF DISABLE pushbutton...release.	___	___	
X TRANSMITTER NOISE meter...decreases 6 μa maximum.	___	___	
TIME FINISHED ________			
PERFORM FOLLOWING TESTS OR BRANCH AND FLOW:			
CENTRAL TESTS:			
TIME STARTED ________			
1. Select pgs. 24-100, 24-111, and 24-115 of functional schematics.	___	___	
TIME FINISHED ________			
TIME STARTED ________			
2. Position 13 of transmitter test set.	___	___	
TIME FINISHED ________			
TIME STARTED ________			
3. Check W2P1 or replace AF-RF amplifier.	___	___	
TIME FINISHED ________			
RELATED TESTS:			
TIME STARTED ________			
1. Replace hi/low frequency amplifier.	___	___	
TIME FINISHED ________			

LIKELY ERRORS: 1. Replace hi/low frequency amplifier after position #13 check.
2. Replace IF amplifier after position #13 check.

PROCEDURE	GO	NO GO	COMMENTS/ERRORS
TIME STARTED ________			
2. Replace IF amplifier.	__	__	
TIME FINISHED ________			

LIKELY ERRORS:	YES	NO	
TIME STARTED ________			
1. Replace hi/low frequency amplifier after position #13 check.	__	__	
TIME FINISHED ________			
TIME STARTED ________			
2. Replace IF amplifier after position #13 check.	__	__	
TIME FINISHED ________			

OTHER ERRORS:

TIME STARTED	TIME FINISHED	DESCRIPTION

FAULT ISOLATION PROCEDURES:

TIME STARTED ________

TIME FINISHED ________

DESCRIPTION: ________________________________

____

STUDENT CORRECTLY IDENTIFIES TROUBLE?

PERFORMANCE TEST FOR HIGH VOLTAGE "WALK THROUGH" PROBLEM

High Voltage Problem

I Bad (Open) PA (Does Not Conduct)

	GO	NO GO	COMMENTS

TIME STARTED ________

1. Radar to off.
2. Disconnect P2 from distribution box.
3. Disconnect NVPSTS PA FIL test cable from dummy jack and connect to P2 on the distribution box.
4. Radar to standby.

1. Set HVPSTS FIL test switch S1 to PA fil volts.
2. Adjust power amp FIL control on panel 1 for red line on HVPSTS FIL test meter.

HVPSTS FIL test meter indicates red line

PA FIL meter on panel indicates red line

1. PA FIL power supply A3 is good.
2. Reconnect cables for normal operation.

Proceed to power amplifier high voltage test.

	GO	NO GO	COMMENTS

Enter from PA filament test

1. Radar to off.
2. Disconnect PA cable from ripple sensing unit.
3. Remove test cable W9 from dummy jack and connect to ripple sensing unit in place of the PA cable.
4. MO beam CB off.
5. PA beam CB on.
6. Radar to PA false radiate.

Check and adjust PA

Beam Amp: .75 - 1.25

Beam Volt: Green area

Regulator Volts: 750-1750

PA indications correct and variable

Did you come to this procedure because of incorrect PA indications

TIME FINISHED ________

TIME STARTED ________

1. Replace the power amplifier tube (PA)
2. reconnect cables for normal operations.

TIME FINISHED ________

INSTRUCTOR RATING SHEET

V. INSTRUCTOR RATINGS

PLACE A CHECK MARK IN THE SPACE THAT YOU THINK BEST DESCRIBES THE STUDENT'S PERFORMANCE IN THIS TASK.

1. How often did the student select proper tools?

____ ____ ____ ____ ____ ____ ____

ALWAYS SOMETIMES NEVER

2. How well did the student use tools?

____ ____ ____ ____ ____ ____ ____

NOT WELL AT ALL MODERATELY WELL VERY WELL

3. How familiar was the student with the names of various pieces of equipment?

____ ____ ____ ____ ____ ____ ____

NOT FAMILIAR AT ALL SOMEWHAT FAMILIAR VERY FAMILIAR

4. To what extent did the student hesitate while performing this task?

____ ____ ____ ____ ____ ____ ____

A GREAT DEAL SOMEWHAT NOT AT ALL

5. How familiar was the student with task-related jargon?

____ ____ ____ ____ ____ ____ ____

VERY FAMILIAR SOMEWHAT FAMILIAR NOT FAMILIAR AT ALL

How many safety violations did the student commit? ____

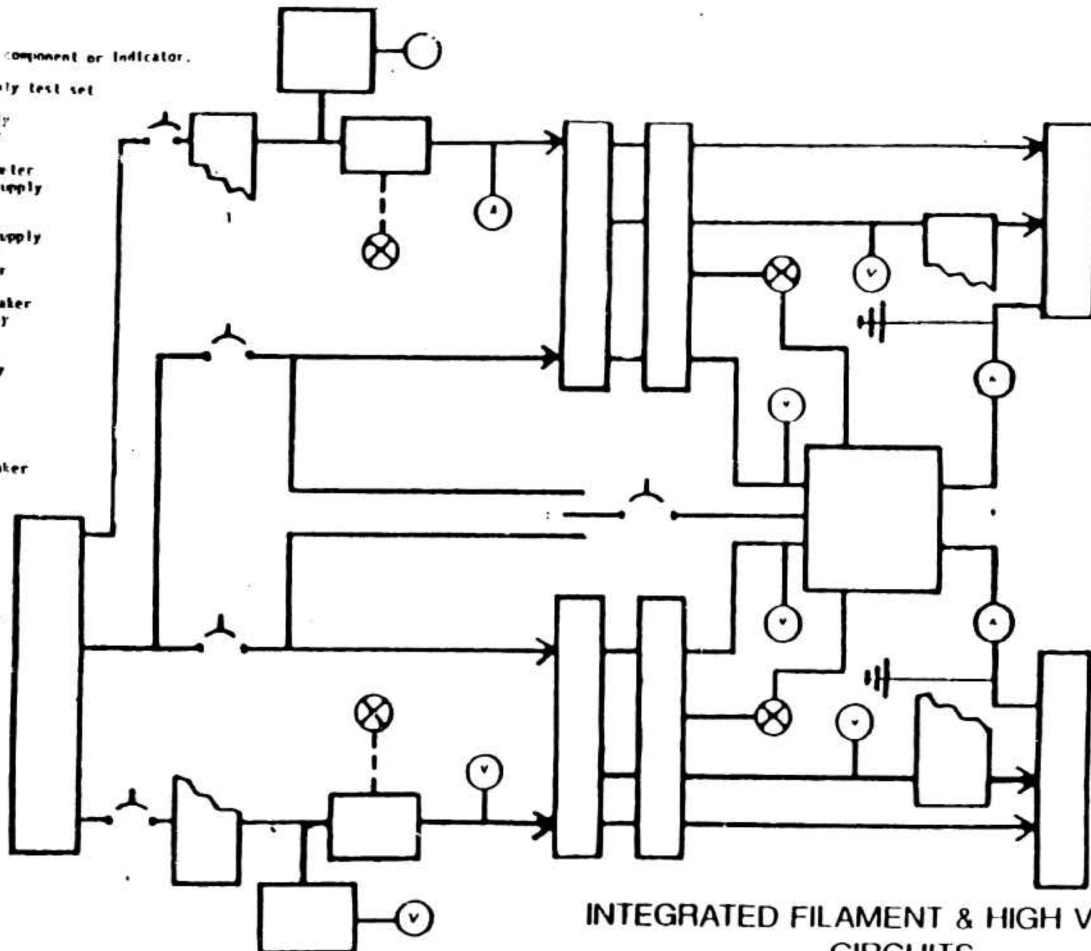
APPENDIX E

PERFORMANCE TESTS USED IN EXPERIMENT 6

COMPONENT LOCATION TEST (WRITTEN)

Place the number inside the component or indicator.

1. High voltage power supply test set
2. High voltage regulator
3. MO filament power supply
4. PA beam circuit breaker
5. Ripple sensing unit
6. degeneration function meter
7. MO high voltage power supply
8. Line voltage regulator
9. Power amplifier
10. PA high voltage power supply
11. MO beam circuit breaker
12. PA regulator volts meter
13. Master oscillator
14. MO filament circuit breaker
15. PA filament Power Supply
16. MO beam amps meter
17. MO filament transformer
18. Contactor relay assembly
19. PA filament volts meter
20. PA beam amps meter
21. Isomodulator
22. MO beam volts meter
23. MO filament adjust
24. PA filament circuit breaker
25. PA beam volts meter
26. Transmitter test set
27. MO filament amps meter
28. Screen and filament circuit breaker
29. PA filament adjust
30. MO voltage adjust
31. PA filament transformer
32. MO regulator volts meter
33. PA voltage adjust



INTEGRATED FILAMENT & HIGH VOLTAGE CIRCUITS

PERFORMANCE TESTS FOR PROBLEMS 10, 11, AND 12

Problem #10

Bad High Volts Regulator (PA Side)

Page 1

	GO	NO GO	COMMENT
TIME STARTED ______			
1. Standby pushbutton press & release.	____	____	
2. MO beam cb on.	____	____	
3. PA beam cb on.	____	____	
4. Regulator volts switch MO.	____	____	
5. Check MO FIL amps meter for 6.3.	____	____	
6. Check PA FIL volts meter for red line.	____	____	
7. Radiate pushbutton press and release.	____	____	
8. Regulator volts meter 1.4 to 1.6 KV.	____	____	
9. Adjust MO beam control.	____	____	
10. MO beam volts meter green area.	____	____	
11. MO beam amperes meter 50 to 100.	____	____	
12. Regulator volts switch to PA.	____	____	
* Reg volts meter .9 to 1.0 KV.	____	____	
* Adjust PA beam volts control.	____	____	
* PA beam volts meter green area.	____	____	
* PA beam amps meter .75 to 1.25.	____	____	
TIME FINISHED ______			
TIME STARTED ______			

Problem #10

Bad High Volts Regulator (PA Side)

Page 2

	GO	NO GO	COMMENT
1. Press and release off pushbutton.	____	____	
2. Disconnect P2 from dist. box.	____	____	
3. Disconnect HVPSTS PA cable from P4 and connect to P2 pos.	____	____	
4. Radar to standby.	____	____	
5. Set HVPSTS Fil test switch to PA Fil volts.	____	____	
6. Adjust PA amp fil control on panel 1 for red line on HVPSTS meter.	____	____	
7. Check PA fil meter on panel 1 for red line.	____	____	
TIME FINISHED ________			
TIME STARTED ________			
1. Press and release off pushbutton.	____	____	
2. Disconnect PA fil test cable from P2 on dist box & reconnect cable to HVPSTS dummy jack.	____	____	
3. Reconnect P2 to dist. box.	____	____	
4. Press & release standby pushbutton.	____	____	
5. Check and adjust PA fil.	____	____	
6. Proceed to PA high voltage check.	____	____	
TIME FINISHED ________			
TIME STARTED ________			

Problem #10

Bad High Voltage Regulator (PA)

Page 3

	GO	NO GO	COMMENT
1. Press and release off pushbutton.	____	____	
2. Disconnect PA cable from ripple sensing unit.	____	____	
3. Remove cable W9 from dummy jack & connect it to RSU in place of PA cable.	____	____	
4. MO beam cb off.	____	____	
5. PA beam cb on.	____	____	
6. Press & release standby pushbutton.	____	____	
7. Press & release radiate pushbutton.	____	____	
TIME FINISHED ________			
TIME STARTED ________			
1. Check & adjust; beam amperes.	____	____	
2. Beam voltage.	____	____	
3. Regulator volts.	____	____	
4. Go to step A.	____	____	
TIME FINISHED ________			
TIME STARTED ________			
1. Press & release standby pushbutton.	____	____	
2. Press & release off pushbutton.	____	____	
3. Disconnect cable W9 from RSU & connect to dummy jack.	____	____	
4. Reconnect PA cable to RSU.	____	____	

Problem #10

Bad High Voltage Regulator (PA)

Page 4

	GO	NO GO	COMMENT
5. Disconnect cable from P2.	____	____	
6. Disconnect cable W12 and connect to P2 pos on distribution box.	____	____	
7. Disconnect cable from P6 pos.	____	____	
8. Disconnect cable W13 from dummy plug under HV Reg & connect to P6 pos on dist. box.	____	____	
9. Disconnect cable from J8 on HV Reg to W1J2 below HV Reg.	____	____	
10. Check M10 beam cb is off; PA beam cb is on.	____	____	
11. Press & release standby pushbutton.	____	____	
12. Press & release radiate pushbutton.	____	____	
TIME FINISHED ________			
TIME STARTED ________			
1. Set HVPSTS high volts test switch to PA B+.	____	____	
2. Check HVPSTS high volts meter.	____	____	
3. Set HVPSTS high volts test switch to PA mult. & PA sense.	____	____	
4. Check HVPSTS high volts meter.	____	____	
5. Go to step B.	____	____	
TIME FINISHED ________			
TIME STARTED ________			

Problem #10

Bad High Voltage Regulator (PA)

Page 5

	GO	NO GO	COMMENT
1. Press & release standby pushbutton.	____	____	
2. Press & release off pushbutton.	____	____	
3. Disconnect cable from WIJ2 & reconnect to J8 on HV Reg.	____	____	
4. Disconnect cable W13 from P6 on dist. box & connect to jack under HV Reg.	____	____	
5. Reconnect cable to P6 pos.	____	____	
6. Check MO beam cb is off; PA cb is on.	____	____	
7. Press standby pushbutton.	____	____	
8. Press radiate pushbutton.	____	____	
TIME FINISHED ________			
TIME STARTED ________			
1. Check & adjust PA: beam amperes.	____	____	
2. Beam voltage.	____	____	
3. Regulator volts.	____	____	
4. Replace high voltage regulator.	____	____	
5. Press standby pushbutton.	____	____	
6. Press off pushbutton.	____	____	
7. Reconnect cable to P2 pos. on distribution box.	____	____	
TIME FINISHED ________			

Problem #11

Bad MO High Voltage Power Supply (A1)

Page 1

	GO	NO GO	COMMENT
TIME STARTED ________			
1. Press & release standby pushbutton.	____	____	
2. MO beam circuit breaker on.	____	____	
3. PA beam circuit breaker on.	____	____	
4. Regulator volts switch MO.	____	____	
5. Check MO fil amps meter for 6.3.	____	____	
6. PA fil voltage meter is red line.	____	____	
7. Press & release radiate pushbutton.	____	____	
* Regulator volts meter 1.4 to 1.6 KV.	____	____	
* Adjust MO beam control.	____	____	
* MO beam volt meter green area.	____	____	
* MO beam amps meter 50 to 100.	____	____	
TIME FINISHED ________			
TIME STARTED ________			
1. Press & release standby pushbutton.	____	____	
2. Press & release off pushbutton.	____	____	
3. Disconnect P1 from distribution box.	____	____	
4. Disconnect HVPSTS MO fil test cable & connect to P1 on dist. box.	____	____	
5. Press & release standby pushbutton.	____	____	
6. Set HVPSTS fil switch to MO fil volts.	____	____	

Problem #11

Bad MO High Voltage Power Supply (A1)

Page 2

	GO	NO GO	COMMENT
7. Adjust MO fil control for red line on HVPSTS fil test meter.	____	____	
8. MO fil amp meter on panel 1 indicates center scale.	____	____	
9. Press off pushbutton.	____	____	
10. Disconnect MO fil test cable from P1 & reconnect to HVPSTS P3.	____	____	
11. Reconnect cable to P1 pos.	____	____	
12. Press standby pushbutton.	____	____	
13. Check & adjust MO fil current.	____	____	
14. Proceed to MO high voltage check.	____	____	
TIME FINISHED ________			
TIME STARTED ________			
1. Press & release off pushbutton.	____	____	
2. Disconnect MO cable from ripple sensing unit.	____	____	
3. Remove W11 from dummy jack & connect to RSU in place of MO cable.	____	____	
4. PA beam cb off.	____	____	
5. MO beam cb on.	____	____	
6. Press & release standby pushbutton.	____	____	
7. Press & release radiate pushbutton.	____	____	
8. Check & adjust MO: beam amperes.	____	____	

Problem # 11

Bad MO High Voltage Power Supply A2

Page 3

	GO	NO GO	COMMENT
9. Beam voltage.	____	____	
10. Regulator volts.	____	____	
11. Go to step A.	____	____	
TIME FINISHED ________			
TIME STARGED ________			
1. Press & release standby pushbutton.	____	____	
2. Press & release off pushbutton.	____	____	
3. Disconnect cable W11 from RSU & connect to dummy jack.	____	____	
4. Reconnect MO cable to RSU.	____	____	
5. Disconnect P1 from dist. box.	____	____	
6. Disconnect cable W10 & connect to P1 pos on distribution box.	____	____	
7. Disconnect cable from P6 on dist. box.	____	____	
8. Disconnect cable W13 from plug under HV reg. & connect to P6 on dist. box.	____	____	
9. Disconnect cable from J8 on HV Reg. & connect to W1J2 below HV Reg.	____	____	
10. Check PA beam cb is off; MO beam cb is on.	____	____	
11. Press & release standby pushbutton.	____	____	
12. Press & release radiate pushbutton.	____	____	
TIME FINISHED ________			
TIME STARTED ________			

Problem #11

Bad MO High Voltage Power Supply A2

Page 4

	GO	NO GO	COMMENT
1. Set HVPSTS high volts test switch S2 to MO B+.	____	____	
2. Check HVPSTS high volts meter.	____	____	
3. Replace MO HV power supply A1.	____	____	
4. Press & release standby pushbutton.	____	____	
5. Press & release off pushbutton.	____	____	
6. Disconnect cable from W1J2 below HV Reg. & connect to J8 on HV Reg.	____	____	
7. Disconnect cable from P6 on dist. box & reconnect to plug under HV Reg.	____	____	
8. Reconnect cable to P6 on dist. box.	____	____	
9. Disconnect cable W10 from P1 pos. & reconnect to wall jack.	____	____	
10. Reconnect cable to P1 pos. on distribution box.	____	____	

TIME FINISHED ________

Problem #12

Bad PA Filament Power Supply A3

Page 1

	GO	NO GO	COMMENT
TIME STARTED __________			
1. Press & release standby pushbutton.	____	____	
2. MO circuit breaker on.	____	____	
3. PA circuit breaker on.	____	____	
4. Regulator volts switch MO.	____	____	
5. Check MO Fil amps meter for 6.3.	____	____	
6. PA fil volts meter is red line.	____	____	
7. Press & release radiate pushbutton.	____	____	
8. Reg. volts meter 1.4 to 1.6 KV.	____	____	
9. Adjust MO beam control.	____	____	
10. MO beam volts meter green area.	____	____	
11. MO beam amps meter 50 to 100.	____	____	
12. Reg. volts switch PA.	____	____	
* Reg volts meter .9 to 1.00.	____	____	
* Adjust PA beam control.	____	____	
* PA beam volts meter green area.	____	____	
* PA beam amps meter .75 - 1.25.	____	____	
TIME FINISHED __________			
TIME STARTED __________			
1. Press & release off pushbutton.	____	____	

Problem #12

Bad PA Filament Power Supply A3

Page 2

	GO	NO GO	COMMENT
2. Disconnect P2 from dist. box.	____	____	
3. Disconnect HVPSTS PA fil test cable & connect to P2.	____	____	
4. Press & release standby pushbutton.	____	____	
5. Set HVPSTS fil test switch to PA fil volts.	____	____	
6. Adjust PA fil contron on Panel 1 for red line on HVPSTS fil test meter.	____	____	
TIME FINISHED ________			
TIME STARTED ________			
1. Replace PA fil power supply A3.	____	____	
2. Check PA fil volts with test cable connected.	____	____	
3. Press off pushbutton.	____	____	
4. Disconnect HVPSTS PA cable from P2. & reconnect to HVPSTS dummy jack.	____	____	
5. Reconnect cable to P2 on dist. box.	____	____	
TIME FINISHED ________			

COMPONENT LOCATION TEST (ORAL)

GRUMMAN ORAL TEST

NAME ______________________

Names and Locations of Parts

I. Recognition of parts (instructor says name - student points out location).

TIME		GO	NO GO	COMMENTS
1.	MO Beam Amperes Meter	____	____	
2.	MO High Voltage Power Supply	____	____	
3.	Regulator Screen and Filament Circuit Breaker	____	____	
4.	PA Filament Voltage Meter	____	____	
5.	Master Oscillator	____	____	
6.	MO Beam Voltage Adjust	____	____	
7.	Regulator Volts Meter	____	____	
8.	MO Filament Circuit Breaker	____	____	
9.	PA Beam Current Meter	____	____	
10.	MO Filament Adjust	____	____	

II. Recall (instructor points to parts - student gives the name).

TIME		GO	NO GO	COMMENTS
1.	High Voltage Regulator	____	____	
2.	High Voltage Power Supply Test Set	____	____	
3.	PA High Voltage Power Supply	____	____	
4.	Ripple Sensing Unit	____	____	
5.	PA Filament Circuit Breaker	____	____	
6.	MO Filament Power Supply	____	____	
7.	Contactor Relay Assembly	____	____	
8.	Power Amplifier	____	____	
9.	MO Beam Voltage Meter	____	____	
10.	PA Filament Power Supply	____	____	